Digitized by the Internet Archive
in 2012 with funding from
CARLI: Consortium of Academic and Research Libraries in Illinois

http://archive.org/details/ecologyofwaterfo00gate

36

ST-4

**HERTZBERG-NEW METHOD, INC.** / Vandalia Road, Jacksonville, Ill.

| TITLE NO./RUB/S.B. | ACCOUNT NO. | LOT AND TICKET NO. |
|---|---|---|
|  | 5640-1 | 15A-14 |

DO NO [illegible] N ABOVE SPACE

CLOTH COLOR: BROWN

COLOR LETTERING: [✓ WHITE] GOLD BLACK

VOLS.

OVE ADS YES ☐ NO ☒

VE COVERS YES ☐ NO ☒

LETTERING FOR SPINE:
ECOLOGY OF WATERFOWL IN
NORTHEASTERN ILLINOIS
W-102-R(SI)

RGING INFORMATION

BBING

D SEW

U SEW

U SEW ON TAPE

HAND ADHESIVE

LENGTHWISE

FOREIGN TITLE

LINES OF LETTERING

FRONT COVER

NO TRIM

PAGES LAMINATED

EXTRA THICKNESS

MAP POCKET PAPER

MAP POCKET CLOTH

SPECIAL WORK

VOL.

MO.

YR. 1992

CALL NO. CWRC

HEIGHT 10 7/8

PICA 4

WRAP 9 5/8

SPECIAL INSTRUCTIONS

3x

**2** PLEASE PEEL OFF AT EXTENDED SHEETS AND SEND COPIES 1 AND 2 (HELD TOGETHER) TO BINDERY NUMERICALLY ARRANGED.

FINAL REPORT

W-102-R(SI)

# ECOLOGY OF WATERFOWL IN NORTHEASTERN ILLINOIS

Submitted by:

Cooperative Wildlife Research Laboratory, SIUC

Presented to:

Illinois Department of Conservation

September 18, 1992

Prepared by:

Robert J. Gates

Robert J. Gates, Assistant Professor
Cooperative Wildlife Research Lab.
Southern Illinois University
Carbondale, IL 62901

Alan Woolf, Director
Cooperative Wildlife Research Lab.
Southern Illinois University
Carbondale, IL 62901

Submitted by:

Alan Woolf, Director
Cooperative Wildlife Research Lab.
Southern Illinois University
Carbondale, IL 62901

# FINAL REPORT

W-102-R(SI)

# ECOLOGY OF WATERFOWL IN NORTHEASTERN ILLINOIS

**Submitted by:**

**Cooperative Wildlife Research Laboratory, SIUC**

**Presented to:**

**Illinois Department of Conservation**

**September 18, 1992**

**Prepared by:**

Robert J. Gates

**Robert J. Gates, Assistant Professor**
**Cooperative Wildlife Research Lab.**
**Southern Illinois University**
**Carbondale, IL 62901**

**Alan Woolf, Director**
**Cooperative Wildlife Research Lab.**
**Southern Illinois University**
**Carbondale, IL 62901**

**Submitted by:**

**Alan Woolf, Director**
**Cooperative Wildlife Research Lab.**
**Southern Illinois University**
**Carbondale, IL 62901**

## TABLE OF CONTENTS

Page

Need . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 1

Objectives . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2

Executive Summary . . . . . . . . . . . . . . . . . . . . . . . . . 2

Non-Breeding Season . . . . . . . . . . . . . . . . . . . . . . . . 4

Introduction . . . . . . . . . . . . . . . . . . . . . . . . 4

Study Area . . . . . . . . . . . . . . . . . . . . . . . . . 5

Job A. Waterfowl Distribution and Abundance . . . . . . . . . . 7

Methods . . . . . . . . . . . . . . . . . . . . . . . . 7

Results and Discussion . . . . . . . . . . . . . . . . . 9

Job B. Habitat Use and Selection . . . . . . . . . . . . . . . 17

Methods . . . . . . . . . . . . . . . . . . . . . . . . 17

Results and Discussion . . . . . . . . . . . . . . . . . 19

Breeding Season . . . . . . . . . . . . . . . . . . . . . . . . . 26

Job A. Waterfowl Distribution and Abundance . . . . . . . . . 26

Job B. Habitat Use and Selection . . . . . . . . . . . . . . . 26

Introduction . . . . . . . . . . . . . . . . . . . . . . . . 26

Study Area . . . . . . . . . . . . . . . . . . . . . . . . . 29

Methods . . . . . . . . . . . . . . . . . . . . . . . . . . 30

Results . . . . . . . . . . . . . . . . . . . . . . . . . . 42

Discussion . . . . . . . . . . . . . . . . . . . . . . . . . 83

Conclusions and Recommendations . . . . . . . . . . . . . . . 102

Job C. Analysis and Report . . . . . . . . . . . . . . . . . . . 104

Non-breeding Season . . . . . . . . . . . . . . . . . . . . 105

Breeding Season . . . . . . . . . . . . . . . . . . . . . . 106

Literature Cited . . . . . . . . . . . . . . . . . . . . . . . . 109

Appendices . . . . . . . . . . . . . . . . . . . . . . . . . . . 123

# FINAL REPORT

STATE OF ILLINOIS

W-102-R(SI)

Project Period: 1 July 1989 through 30 June 1992

Study: Ecology of Waterfowl in Northeastern Illinois

Prepared by Robert J. Gates and Alan Woolf
Cooperative Wildlife Research Laboratory
Southern Illinois University at Carbondale

Need: Northeastern Illinois is included as part of the Upper Mississippi River and Great Lakes Region Joint Venture of the North American Waterfowl Management Plan (NAWMP). Goals of this joint venture are to enhance waterfowl and other wetland wildlife populations through protection, creation, and restoration of wetland and associated upland habitats (U. S. Fish and Wildl. Serv. 1992). Northeastern Illinois contains relatively high densities of glacial marshes and other wetlands that are unique to Illinois. Although these wetlands support viable breeding populations of waterfowl and other wetland birds, there is little information on the current status of wetland habitats and waterfowl populations over the region. Northeastern Illinois has been heavily impacted by agricultural and urban development. There has been substantial loss of upland nesting habitat, while natural wetlands have been drained, filled, or converted to open excavated ponds and impoundments. Urbanization appears to have promoted increases in populations of wintering waterfowl and resident giant Canada geese (Branta canadensis maxima) that are increasingly perceived by the public as a nuisance. Knowledge and understanding of abundance, distribution, and habitat use patterns of breeding and non-breeding waterfowl are needed to implement effective wetland habitat and population management programs in northeastern Illinois. Identification of physical and biotic characteristics of wetland habitats selected by waterfowl in northeastern Illinois will facilitate identification of priority wetlands for protection, enhancement, and/or management.

Objectives:

1. To estimate current distribution and abundance of waterfowl (with emphasis on mallards, Canada geese, and wood ducks) in northeastern Illinois during breeding season and winter.

2. To document habitat use and selection by waterfowl during the breeding season and winter.

3. To integrate published data and findings from these studies into recommendations for habitat protection, enhancement, and management.

## EXECUTIVE SUMMARY

As initially conceived, this project was to emphasize work with giant Canada geese (Branta canadensis maxima). The original Application for Federal Aid (AFA) included a job dealing with local movements and fall/winter migrations of resident adult female giant Canada geese. Members of the project coordinating committee (personnel of the Illinois Dept. of Conservation, SIUC Cooperative Wildlife Research Laboratory, and Max McGraw Wildlife Foundation) met in May 1989 to discuss planning and implementation of the project. Waterfowl research priorities were reevaluated in light of potential initiatives under the North American Waterfowl Management Plan for northeastern Illinois. Because the Illinois Department of Conservation (IDOC) has limited ability to manage Canada geese in urban environments of northeastern Illinois, the committee agreed that study objectives should deemphasize giant Canada geese and instead place a more general emphasis on all breeding and non-breeding waterfowl, and their wetland habitats in northeastern Illinois. Consequently, the AFA was amended in June 1990 with the revised objectives and jobs that appear in this report. Revision of the AFA affected only objective 3 (to describe local movements and fall/winter migrations of adult female Canada geese) of the original AFA. This objective was addressed indirectly through seasonal comparisons of distributions and habitats used by Canada geese.

For coherence of presentation, this report is organized as 3 major sections. Methods, results, and discussion of all work conducted during the non-breeding season are presented in the first section, followed by a section dealing with the breeding season. Distribution and abundance (Job A) and habitat selection and use (Job B) are addressed as separate subsections under the non-breeding report section. Methods and results pertaining to Jobs A and B during the breeding season are reported together under an integrated section dealing with distribution, abundance, and habitat use and selection during the breeding season. The third section presents management recommendations that encompass breeding and non-breeding seasons (Job C). Portions of Jobs A - C pertaining to the breeding season were excerpted and revised from a thesis titled "Population Densities and Use of Palustrine Wetlands by Breeding Waterfowl in Northeastern Illinois.", prepared by Mr. Aaron P. Yetter in partial fulfillment of the requirements for the Degree of Master of Science in the Department of Zoology at Southern Illinois University, Carbondale (SIUC). Tables (excerpted from M. S. thesis) summarizing observations of major plants, threatened / endangered and special interest wetland birds, invertebrate taxa, and all species of waterfowl encountered on wetland surveys conducted during spring appear in Appendices A - X of this report. Scientific names of plant and animal species observed on northeastern Illinois wetlands that are mentioned in the text of this report appear in Appendixes A, B, and N.

Robert A. Montgomery (Max McGraw Wildlife Foundation) was Co-principal Investigator on this project. Mr. Montgomery was instrumental in the initial planning and development of this research project, and provided valuable logistical support and advice in the execution of field work. Max McGraw Wildlife Foundation and the Illinois Department of Conservation provided housing for field personnel.

## NON-BREEDING SEASON

### INTRODUCTION

Fall and winter populations of waterfowl, particularly Canada geese and mallards, (Anas platyrhynchos) appear to have increased in northeastern Illinois as urban developments have expanded into areas formerly devoted primarily to agricultural land use. Urban expansion in northeastern Illinois has created refuge areas that are interspersed with remaining agricultural lands that provide winter feeding habitats. Additionally, newly created urban developments (corporate office complexes, housing subdivisions, and golf courses) typically include numerous permanent water bodies that provide roosting and resting areas for migrating and wintering waterfowl. Many of these ponds and small lakes are kept ice-free during the winter by aeration or pumping warm water from cooling systems of corporate and industrial complexes. The combination of urban refuge, open water, and availability of high energy crop foods provide attractive winter and fall migration habitat for large numbers of Canada geese and other waterfowl in northeastern Illinois.

Expanding waterfowl populations in urban areas of northeastern Illinois, are increasingly perceived as a nuisance. Effective population control of resident Canada goose populations is difficult because hunting is prohibited within municipal boundaries. Special hunting seasons have been difficult to implement because of concerns about harvesting migrant Canada geese that pass through the area during fall and early winter. Recent early hunting seasons have not produced sufficient harvests to control resident Canada goose populations.

Basic population, distribution, and habitat use data are needed to formulate management programs and decisions that affect fall and winter populations and habitats of waterfowl in northeastern Illinois. Data on relative abundance and distribution of waterfowl are lacking because of logistical difficulties associated with the urban environment of northeastern Illinois. This study provided an opportunity to evaluate the efficacy of low altitude aerial population surveys conducted from helicopter in semi-rural and urban areas of northeastern Illinois.

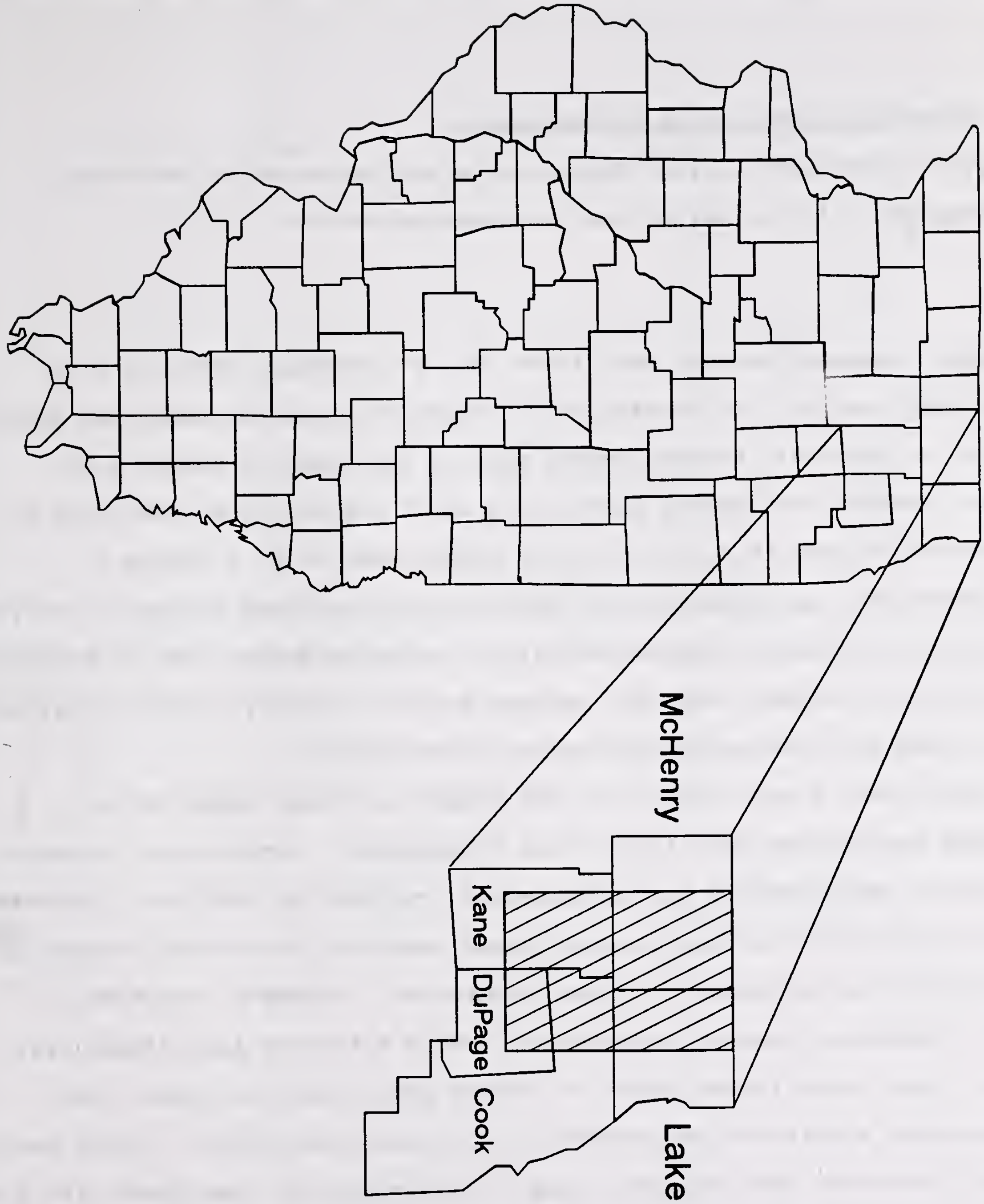
This section reports the results of 4 aerial surveys flown between January 1990 and January 1991 in northeastern Illinois to determine seasonal patterns and changes in relative abundance, distribution, and habitat use of Canada geese, mallards, and other waterfowl during the 1990 and 1991 non-breeding seasons. Relative abundance and distribution of mallards and Canada geese were compared between surveys conducted in different seasons and years, and between portions of 5 northeastern Illinois counties included in the survey area. Habitat composition surrounding locations where waterfowl were observed was compared to the overall availability of upland and wetland habitats.

The Ducks Unlimited, Inc. (DUI) Habitat Inventory and Evaluation Program provided satellite imagery and National Wetlands Inventory (NWI) data to classify upland and wetland habitats. J. E. Jacobson and R. P. Kollasch (DUI) provided training and technical assistance with satellite image processing and data base development. G. T. Koeln (DUI) provided administrative assistance. Aircraft and pilots were provided by U.S. Army Reserve Co. B, 2/228 TAC based at Glenview Naval Air Station, and by a private contractor. T. P. Hollenhorst (CWRL) digitized flock locations, assisted with image interpretation, and performed data analyses. R. A. Montgomery, S. Byers (Max McGraw Wildlife Foundation), R. A. Williamson (Illinois Department of Conservation), John G. Bruggink, D. M. Hertlein, T. P. Hollenhorst, C. P. McMurl, and A. P. Yetter volunteered their time as observers.

## STUDY AREA

The study was conducted in portions of western Lake, eastern McHenry and Kane, northern DuPage, and northwestern Cook counties of Illinois (Figure 1). To correspond with availability of NWI data and satellite imagery used to develop a habitat data base, the primary study area included an area circumscribed by 20 U. S. Geological Survey 7.5' quadrangle maps. The 2,870

Figure 1. Primary 2,870 km$^2$ study area in which aerial and ground surveys of breeding and non-breeding waterfowl populations were conducted during January 1990 through June 1991. Cross-hatched area represents the area covered by 20 U. S. Geological Survey 7.5 minute quadrangle maps for which National Wetlands Inventory data were available. See text for further explanation of additional areas surveyed from helicopter during the non-breeding season.


McHenry
Kane
DuPage
Cook
Lake

$km^2$ area so defined was a block of 4 maps east to west and 5 maps north to south, with corner quadrangles Hebron (northwest), Antioch (northeast), Lombard (southeast), and Elburn (southwest) (Figure 2). Aerial population survey boundaries were extended beyond the primary study area as described below.

## JOB A. Waterfowl Distribution and Abundance

Objective: To estimate current distribution and abundance of waterfowl in northeastern Illinois during the non-breeding season.

### METHODS

Aerial transect surveys were flown 18 - 20 September 1990, 14 - 16 December 1990, and 26 - 27 January 1991. Areas surveyed included Lake County west of U. S. Route 45, McHenry County east of the towns of Hebron and Woodstock, eastern Kane County within 3-10 km of the Fox River and north of the east-west tollway (U.S. Rt. 5), Cook County west of U. S. Route 53/Interstate 290, and DuPage County north of the east-west tollway. Outlying areas were also surveyed opportunistically, including Baxter Labs in southern Lake County, and Chicago Botanical Gardens and the vicinity (3 km radius) of Glenview Naval Air Station in northeastern Cook County.

Surveys were flown with 2 Bell Jet Ranger (military model OH-58) helicopters each manned with 1 pilot and 2 observers. North-south transects were flown at approximately 1.6 km intervals from 0930 to 1630 CST. Transects were flown at 90-150 m altitudes with ground speeds of 70-120 kph, depending on wind conditions and amount of urban congestion. Attempts were made to survey 0.8 km either side of the aircraft, but 0.4 km were most effectively surveyed. Most large flocks (>200) of Canada geese near open water were easily detected within 0.8 km because of their high visibility. Flight paths temporarily deviated from transect lines to intentionally view areas likely to harbor waterfowl. Transects were navigated by following section lines on Illinois Department of Transportation (IDOT) county general highway maps

Figure 2. Names and orientation of 20 U. S. Geological Survey 7.5 minute maps that defined the 2,870 km$^2$ primary waterfowl population survey area in northeastern Illinois.

|  |  |  |  |
|---|---|---|---|
| Hebron | Richmond | Fox Lake | Antioch |
| Woodstock | McHenry | Wauconda | Grayslake |
| Huntley | Crystal Lake | Barrington | Lake Zurich |
| Pingree Grove | Elgin | Stream-wood | Palatine |
| Elbern | Geneva | West Chicago | Lombard |

(scale 2.5 cm = 1.6 km). The species, number, and locations of waterfowl observed were recorded on IDOT highway maps and data forms.

Chi-square analyses were used to test the hypothesis that Canada geese and mallards were distributed randomly among portions of the 5 counties included in the aerial survey area. Proportions of total flocks and birds observed were compared to proportions expected from total transect lengths flown in each county, across and within surveys. Bonferroni *z* tests were used to identify counties where proportions of total flocks and total birds observed deviated from expected (Neu et al. 1974).

## RESULTS AND DISCUSSION

### Distribution and Abundance

Total distances covered along preselected aerial transects varied among surveys, depending on time and weather constraints. Lengths of transect flown varied from 1,454 km in December 1990 to 1,759 km in January 1990. (Table 1). Total numbers of waterfowl observed on transects varied from 12,638 birds in September 1990 to 45,850 birds in December 1990. Canada geese accounted for 74%-90% of waterfowl observed, while mallards and black ducks (*Anas rubripes*) accounted for 9%-21% of observations.

About twice as many geese were counted in December 1990 as were observed in January 1990 and 1991 (Table 1). Half as many geese were counted in September 1990, compared to January 1990 and 1991. The September 1990 survey was conducted just before migrant Mississippi Valley Population (MVP) Canada geese began arriving in southern Illinois and east-central Wisconsin from their breeding grounds in northern Ontario. Consequently, this survey most closely represented the post-breeding population of resident geese on the study area. The December 1990 survey was conducted during peak migration of MVP Canada geese between east-central Wisconsin and southern Illinois (IDOC, unpubl. data) and likely included a large proportion of nonresident migrating geese. The 2 January surveys indicated a core wintering population of at least 20,000 birds that may have included some wintering birds from

Table 1. Total numbers of waterfowl observed on aerial transects flown during January 1990 - 1991 in portions of Cook, DuPage, Kane, Lake, and McHenry Counties, Illinois.

| | | January 1990 | September 1990 | December 1990 | January 1991 |
|---|---|---|---|---|---|
| | | 1759 km$^{2}$ | 1722 km | 1454 km | 1586 km |
| Canada goose | No. | 22,331 | 8,985 | 43,268 | 19,373 |
| | No./km | 12.7 | 5.2 | 29.8 | 12.2 |
| Mallard | No. | 6,204 | 2,690 | 4,023 | 2,469 |
| | No./km | 3.5 | 1.6 | 2.8 | 1.6 |
| Black duck | No. | 30 | 0 | 169 | 0 |
| | No./km | <0.1 | 0.0 | 0.1 | 0.0 |
| Wood duck | No. | 0 | 78 | 50 | 0 |
| | No./km | 0.0 | <0.1 | <0.1 | 0.0 |
| Mute swan | No. | 9 | 102 | 123 | 84 |
| | No./km | <0.1 | 0.1 | 0.1 | <0.1 |
| Goldeneye | No. | 699 | 0 | 144 | 860 |
| | No./km | 0.4 | 0.0 | 0.1 | 0.5 |
| Other waterfowl | No. | 0 | 437[b] | 5[c] | 0 |
| | No./km | 0.0 | 0.2 | <0.1 | 0.0 |
| All species | No. | 29,273 | 12,292 | 47,782 | 22,786 |
| | No./km | 16.6 | 7.1 | 32.9 | 14.4 |

[a] Total kilometers of transect flown.

[b] Blue-winged teal and unidentified species.

[c] Snow geese.

other populations in addition to resident geese. The September 1990 survey indicated a minimum population of nearly 10,000 birds that probably consisted mostly of breeding adults and their young.

Except for mute swans (Cygnus olor) and perhaps goldeneyes (Bucephala spp.) that were relatively conspicuous, numbers of other waterfowl observed in each survey probably did not reliably reflect actual population sizes. Mute swans were easily detected and counts of this species were considered fairly complete. The 3 surveys conducted September 1990 - January 1991 indicated a population of approximately 100 swans (Table 1). Reasons for the low number of swans observed in January 1990 were unknown. Detectibility of ducks was especially low in September when tree leaves and other green vegetation partially or totally obscured many small lakes, ponds, and marshes.

Canada geese were not randomly distributed among portions of the 5 northeastern Illinois counties included in the study area (Tables 2 and 3). Larger proportions ($P < 0.05$) of Canada geese were generally observed in Cook and DuPage Counties than was expected from total km of transects flown. Fewer ($P < 0.05$) geese were observed than expected in Lake, McHenry, and Kane Counties during nearly all surveys. Consequently, the greatest densities (birds/km of transect) of Canada geese were observed in the relatively urban counties of Cook and DuPage, while lower densities were observed in the more rural counties of Kane, Lake, and McHenry (Figure 3).

Relative distributions of mallards among the 5 counties was somewhat more uniform than observed for Canada geese, but still differed from random (Tables 2 and 3). Kane and DuPage counties generally accounted for greater ($P < 0.05$) proportions of mallard observations than expected, while Lake and McHenry counties had fewer ($P < 0.05$) mallards observed than expected if birdswere distributed randomly across surveyed areas. Kane, DuPage, and Cook counties tended to have the greatest densities of mallards/km of transect, while densities were generally lowest for Lake and McHenry Counties (Figure 3).

Table 2. Total numbers of Canada geese and mallards observed during 4 aerial transect surveys conducted over 5 northeastern Illinois counties, compared with numbers expected from total km of transect flown if birds were distributed randomly among counties.

| Survey<br>Species | | Cook | DuPage | Kane | Lake | McHenry |
|---|---|---|---|---|---|---|
| January, 1990 | | | | | | |
| Canada goose | Observed | 7,625 | 9,514 | 2,210 | 1,103 | 1,879 |
| | Expected | 3,887 | 3,874 | 2,184 | 4,700 | 7,685 |
| | | $P < 0.05$ | $P < 0.05$ | NS | $P < 0.05$ | $P <0.05$ |
| | Overall $X^2$ | | | 18,944 | | |
| | $P$ | | | <0.001 | | |
| Mallard | Observed | 1,311 | 984 | 1,546 | 542 | 1,821 |
| | Expected | 1,080 | 1,076 | 607 | 1,306 | 2,135 |
| | | $P < 0.05$ | $P < 0.05$ | $P < 0.05$ | $P < 0.05$ | $P <0.05$ |
| | Overall $X^2$ | | | 2,003 | | |
| | $P$ | | | <0.001 | | |
| September, 1990 | | | | | | |
| Canada goose | Observed | 2,294 | 2,233 | 945 | 1,544 | 1,969 |
| | Expected | 996 | 1,262 | 1,293 | 2,268 | 3,165 |
| | | $P < 0.05$ | $P < 0.05$ | $P < 0.05$ | $P < 0.05$ | $P <0.05$ |
| | Overall $X^2$ | | | 3,216 | | |
| | $P$ | | | <0.001 | | |
| Mallard | Observed | 350 | 618 | 661 | 159 | 902 |
| | Expected | 298 | 378 | 387 | 679 | 948 |
| | | $P < 0.05$ | $P < 0.05$ | $P < 0.05$ | $P < 0.05$ | NS |
| | Overall $X^2$ | | | 756 | | |
| | $P$ | | | <0.001 | | |
| December, 1990 | | | | | | |
| Canada goose | Observed | 11,478 | 15,675 | 5,633 | 7,735 | 2,747 |
| | Expected | 6,517 | 7,201 | 9,820 | 11,844 | 7,886 |
| | | $P < 0.05$ | $P < 0.05$ | $P < 0.05$ | $P < 0.05$ | $P <0.05$ |
| | Overall $X^2$ | | | 20,306 | | |
| | $P$ | | | <0.001 | | |

Table 2. Continued.

| Survey<br>Species | | Cook | DuPage | Kane | Lake | McHenry |
|---|---|---|---|---|---|---|
| December, 1990 | | | | | | |
| Mallard | Observed | 650 | 1,730 | 1,133 | 450 | 70 |
| | Expected | 607 | 671 | 915 | 1,104 | 735 |
| | | NS | $P < 0.05$ | $P < 0.05$ | $P < 0.05$ | $P < 0.05$ |
| | Overall $X^2$ | | | 2,714 | | |
| | $P$ | | | <0.001 | | |
| January, 1991 | | | | | | |
| Canada goose | Observed | 2,335 | 12,903 | 1,298 | 1,995 | 842 |
| | Expected | 2,640 | 2,383 | 4,645 | 4,620 | 5,085 |
| | | $P < 0.05$ | $P < 0.05$ | $P < 0.05$ | $P < 0.05$ | $P < 0.05$ |
| | Overall $X^2$ | | | 53,907 | | |
| | $P$ | | | <0.001 | | |
| Mallard | Observed | 175 | 302 | 1,014 | 540 | 438 |
| | Expected | 336 | 304 | 592 | 589 | 648 |
| | | $P < 0.05$ | NS | $P < 0.05$ | NS | $P < 0.05$ |
| | Overall $X^2$ | | | 450 | | |
| | $P$ | | | <0.001 | | |

Table 3. Total flocks of Canada geese and mallards observed during 4 aerial transect surveys conducted over 5 northeastern Illinois counties, compared with numbers expected from total km of transect flown if birds were distributed randomly among counties.

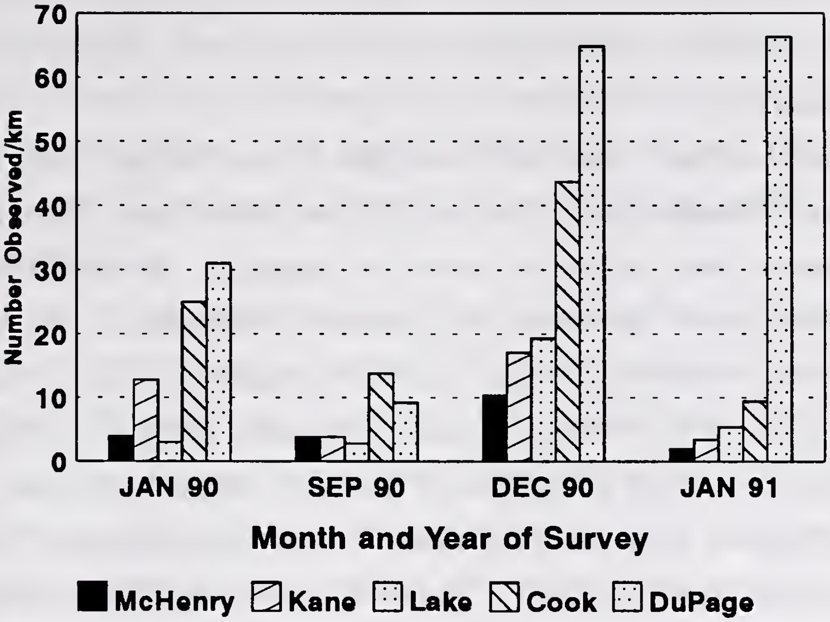
| Survey<br>Species | | Cook | DuPage | Kane | Lake | McHenry |
|---|---|---|---|---|---|---|
| January, 1990 | | | | | | |
| Canada goose | Observed | 46 | 54 | 18 | 20 | 15 |
| | Expected | 27 | 26 | 15 | 32 | 53 |
| | | $P < 0.05$ | $P < 0.05$ | NS | $P < 0.05$ | $P < 0.05$ |
| | Overall $X^2$ | | | 74.6 | | |
| | $P$ | | | $<0.001$ | | |
| Mallard | Observed | 42 | 35 | 27 | 17 | 27 |
| | Expected | 26 | 26 | 14 | 31 | 51 |
| | | $P < 0.05$ | NS | $P < 0.05$ | $P <0.05$ | $P < 0.05$ |
| | Overall $X^2$ | | | 42.1 | | |
| | $P$ | | | $<0.001$ | | |
| September, 1990 | | | | | | |
| Canada goose | Observed | 71 | 61 | 26 | 43 | 28 |
| | Expected | 25 | 32 | 33 | 58 | 81 |
| | | $P < 0.05$ | $P < 0.05$ | NS | NS | $P < 0.05$ |
| | Overall $X^2$ | | | 147.5 | | |
| | $P$ | | | $<0.001$ | | |
| Mallard | Observed | 21 | 26 | 40 | 8 | 24 |
| | Expected | 13 | 17 | 17 | 30 | 42 |
| | | $P < 0.05$ | NS | | $P <0.05$ | $P < 0.05$ |
| | Overall $X^2$ | | | 64.2 | | |
| | $P$ | | | $<0.001$ | | |
| December, 1990 | | | | | | |
| Canada goose | Observed | 81 | 73 | 52 | 78 | 27 |
| | Expected | 46 | 52 | 71 | 85 | 57 |
| | | $P < 0.05$ | $P < 0.05$ | NS | $P < 0.05$ | $P < 0.05$ |
| | Overall $X^2$ | | | 54.6 | | |
| | $P$ | | | $<0.001$ | | |

Table 3. Continued.

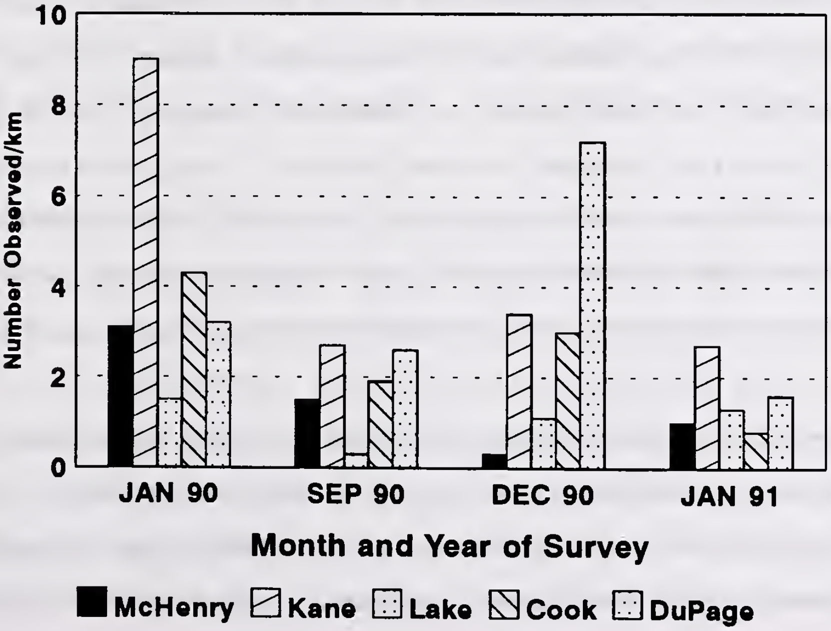
| Survey<br>Species | | Cook | DuPage | Kane | Lake | McHenry |
|---|---|---|---|---|---|---|
| December, 1990 | | | | | | |
| Mallard | Observed | 29 | 53 | 27 | 7 | 4 |
| | Expected | 18 | 20 | 27 | 33 | 22 |
| | | NS | $P < 0.05$ | NS | $P < 0.05$ | $P < 0.05$ |
| | Overall $X^2$ | | 96.2 | | | |
| | $P$ | | <0.001 | | | |
| January, 1991 | | | | | | |
| Canada goose | Observed | 8 | 16 | 11 | 14 | 8 |
| | Expected | 8 | 7 | 14 | 14 | 15 |
| | | NS | $P < 0.05$ | NS | | $P < 0.05$ |
| | Overall $X^2$ | | 15.3 | | | |
| | $P$ | | <0.001 | | | |
| Mallard | Observed | 4 | 5 | 12 | 12 | 14 |
| | Expected | 6 | 6 | 11 | 11 | 12 |
| | | NS | NS | NS | NS | NS |
| | Overall $X^2$ | | 1.3 | | | |
| | $P$ | | >0.001 | | | |

Figure 3. Densities (birds/km) of Canada geese and mallards observed along aerial transects flown with helicopter over portions of 5 northeastern Illinois counties during January 1990 - January 1991.

# Canada geese



# Mallards



## JOB B: Habitat Use and Selection

Objective: To document habitat use and selection by waterfowl during the non-breeding season.

## METHODS

### Habitat Data Base

A computerized data base was developed to record the location, total area, and habitat composition of palustrine wetlands identified from National Wetlands Inventory (NWI) data and satellite imagery. An associated data base was developed to record the locations, numbers, and species of waterfowl observed on aerial transects during the post-breeding season. Satellite imagery using 6 bands (3 visible, 1 near infrared, and 2 mid infrared) of reflectance data collected by Landsat 5 Thematic Mapper (TM) was used to classify upland areas as urban-developed, forested-undeveloped, and open-undeveloped (mostly agricultural). Wetland (NWI) data was rasterized and merged with the satellite TM data to produce a composite habitat map (25 m pixel resolution) and data base for the primary study area. The satellite data was collected on 11 June 1988 and NWI data was derived from aerial photographs dated spring or fall 1980-84.

After merging NWI and TM data and classifying uplands, unclassified pixels with spectral signatures indicating surface water or highly saturated soil were classified as lake, pond, or temporary emergent wetland depending on their location relative to other wetland pixels. Thus, TM data were used to update changes since NWI (newly expanded, impounded, or excavated ponds and lakes) and to identify farmed ephemeral and temporary wetlands not included in NWI. No attempt was made to evaluate wetland losses that occurred after NWI using TM data.

Initial wetland classification was based on NWI designations that identified 186 unique wetland types in the primary study area. System, subsystem, and class NWI codes (Cowardin et al. 1979) were consolidated into lacustrine (lakes), riverine (rivers, streams, and ditches), undeveloped pond (palustrine open water, aquatic bed, unconsolidated shore, and unconsolidated bottom NWI classes) modified pond, (impounded or excavated), palustrine wooded (forested and scrub/shrub NWI classes) and palustrine emergent categories. Water regime modifiers were used to further separate the palustrine emergent category into temporary (temporary and saturated water regimes), seasonal (seasonal water regime), and semi-permanent (semi-permanent and permanent water regimes) wetland types. NWI special modifiers (diked, impounded, or excavated) were used to separate undeveloped and modified ponds.

## Habitat Use and Selection

Locations of flocks recorded on Illinois Department of Transportation county highway maps during aerial surveys were digitized only in areas covered by transects where NWI data was available (i.e. within the 2,870 km$^2$ primary study area). A 0.6 km radius buffer was placed around each flock location that was digitized to the coordinates of a computer map of upland and wetland habitats. Percent composition of upland and wetland habitats within the 1-km$^2$ area surrounding each flock location was measured using a geographic information system (Map and Image Processing System, MicroImages, Inc., Lincoln, NE). Mean percent composition of upland, wetland, and deepwater habitats was calculated and compared between total areas surveyed, and locations where Canada geese and mallards were observed. Upland habitat types included wooded, urban, and idle / agricultural areas, wetland habitat types were ponds and emergent or wooded marshes, and deepwater habitats consisted of lakes and rivers.

Habitat composition within a 1 km$^2$ area surrounding flock locations were compared to overall habitat composition for portions of each county included in the 20 quadrangle map area where habitat types were classified. Percent composition of 3 upland (wooded, urban, idle/agricultural) and 3 aquatic (pond, marsh, deepwater) habitat categories classified in each county were subtracted from values determined within a 1 km$^2$ circle surrounding each flock location. Factorial analysis of variance and t - tests were used to test hypotheses that habitat composition surrounding flock locations differed from overall habitat composition in each county. All statistical tests were considered significant at $\underline{P} \leq 0.05$.

## RESULTS AND DISCUSSION

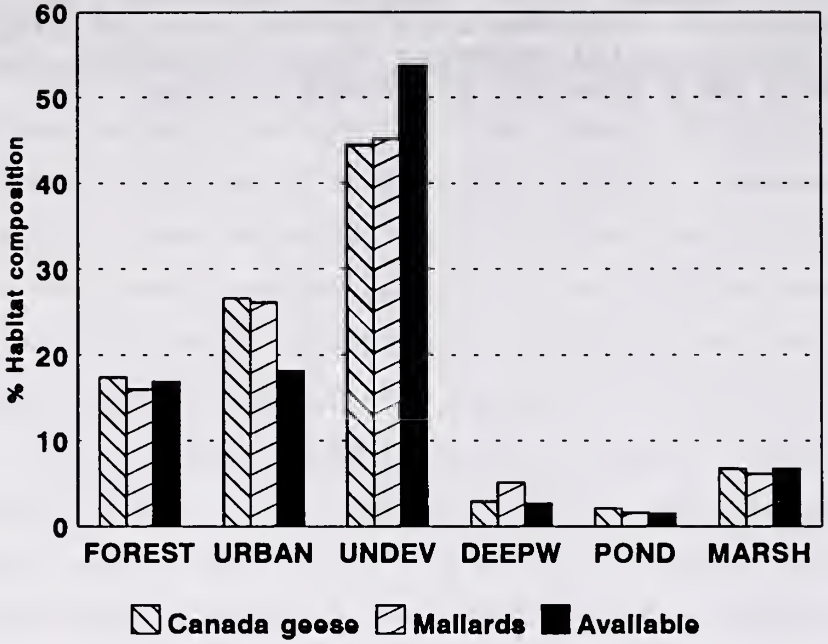
Habitat composition surrounding locations of Canada goose and mallard flocks observed during aerial surveys conducted January 1990-91 broadly reflected the overall distribution of available habitats. However, there were notable differences between upland and wetland habitat composition surrounding flock locations, and overall habitat composition for the areas surveyed. Combining data for all counties and from all 4 surveys, 1 $km^2$ areas surrounding Canada goose and mallard flocks locations included more urban ($\underline{t}$ - test, $\underline{P} < 0.001$) and less undeveloped (idle/agricultural) ($\underline{t}$ - test, $\underline{P} < 0.001$) lands than were available within the 2,870 $km^2$ study area (Figure 4). There were greater proportions ($\underline{t}$ - test, $\underline{P} \leq 0.040$) of urban lands surrounding Canada goose and mallard flock locations than was available even in the more urban counties of Cook and Dupage (Figures 4 and 5). Similar tendencies for greater proportions of urban, and lower proportions of undeveloped lands surrounding Canada goose and mallard flock locations were observed in the more rural Kane, Lake, and McHenry counties, although differences were not always significant (Figures 5 - 6).

Surprisingly, there were few differences in wetland habitat composition between flock locations and areas surveyed. Combining all counties and surveys, mallard flock locations were associated with greater proportions ($\underline{t}$ - test, $\underline{P} = 0.004$) of deepwater habitats (lakes and rivers) than was available (Figure 4). Areas surrounding Canada goose flock locations included greater proportions ($\underline{t}$ -test, $\underline{P} = 0.001$) of pond habitat than was available. These overall differences in wetland habitat composition were attributable mostly to differences that occurred in Kane, Lake, and McHenry Counties (Figures 5 - 6).

Associations of Canada goose and mallard flock locations with upland and wetland habitat types did not differ among surveys (Figures 7 and 8). In all

Figure 4. Mean composition of 3 upland and 3 wetland habitats within 1 $km^2$ surrounding locations where flocks of Canada geese and mallards were observed during aerial transect surveys conducted in portions of 5 northeastern Illinois counties during January 1990 - January 1991. Habitat composition surrounding flock locations are compared with habitat availability in portions of all counties surveyed (top) and within Cook County (bottom), with data from all 4 surveys combined.

**All Counties**



**Cook County**

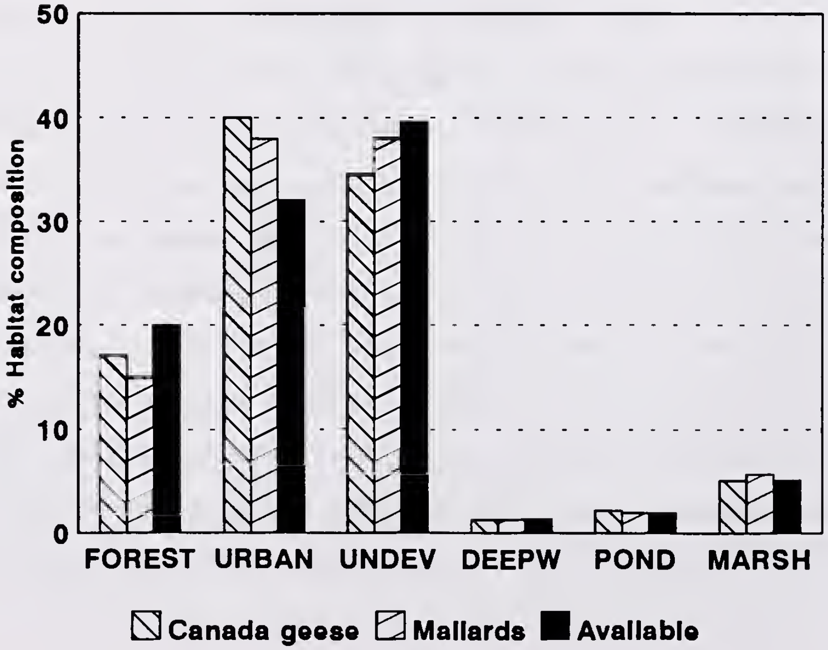
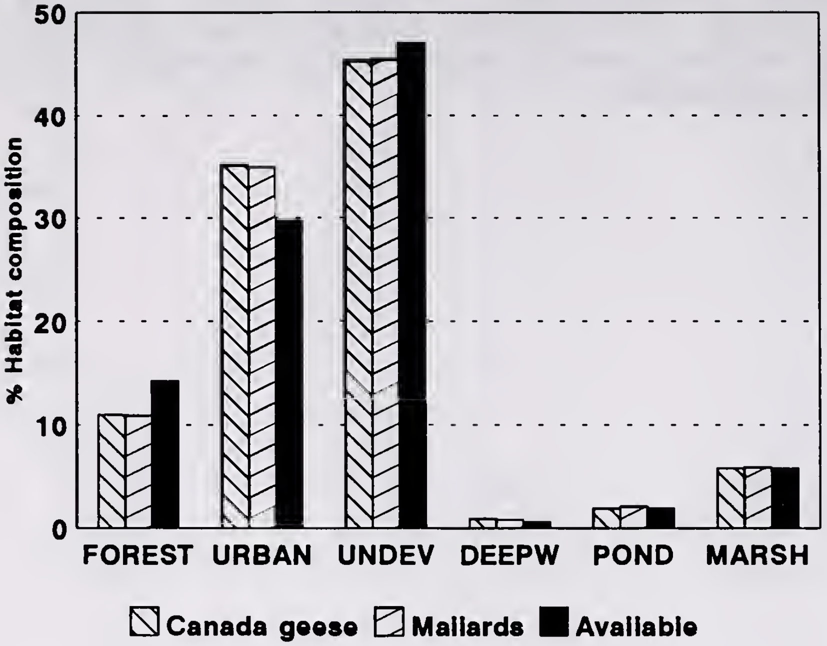


Figure 5. Mean composition of 3 upland and 3 wetland habitats within 1 km$^2$ surrounding locations where flocks of Canada geese and mallards were observed during aerial transect surveys conducted in portions of DuPage and Kane Counties in northeastern Illinois during January 1990 - January 1991. Habitat composition surrounding flock locations are compared with habitat availability in portions of each county surveyed, with data from all 4 surveys combined.


DuPage County

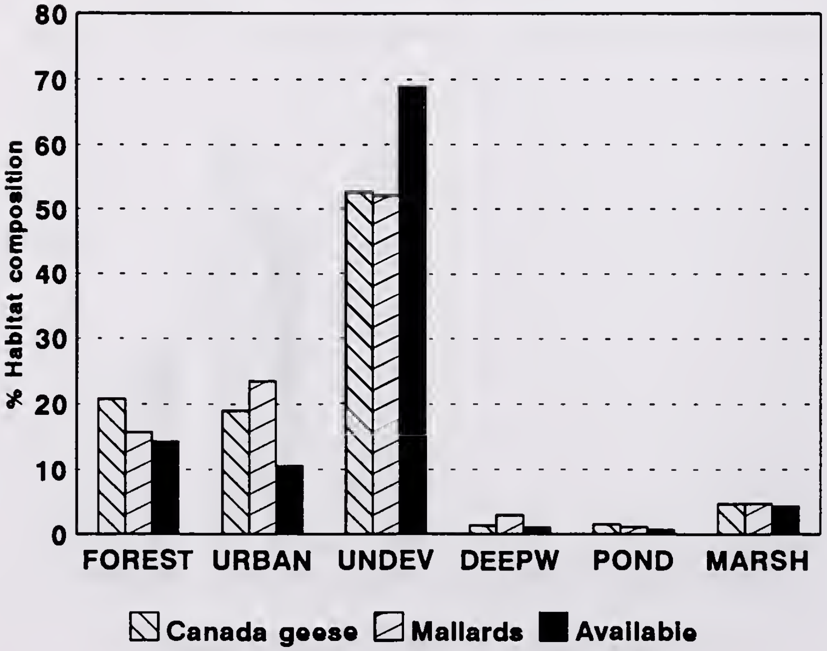
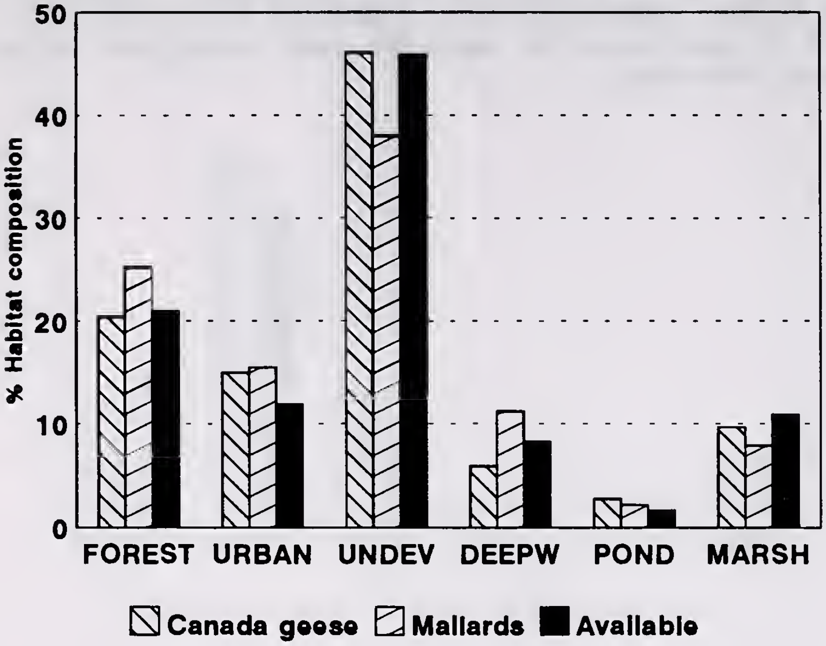

Kane County

Figure 6. Mean composition of 3 upland and 3 wetland habitats within 1 km$^2$ surrounding locations where flocks of Canada geese and mallards were observed during aerial transect surveys conducted in portions Lake and McHenry Counties in northeastern Illinois during January 1990 - January 1991. Habitat composition surrounding flock locations are compared with habitat availability in portions of each county surveyed, with data from all 4 surveys combined.

**Lake County**



**McHenry County**

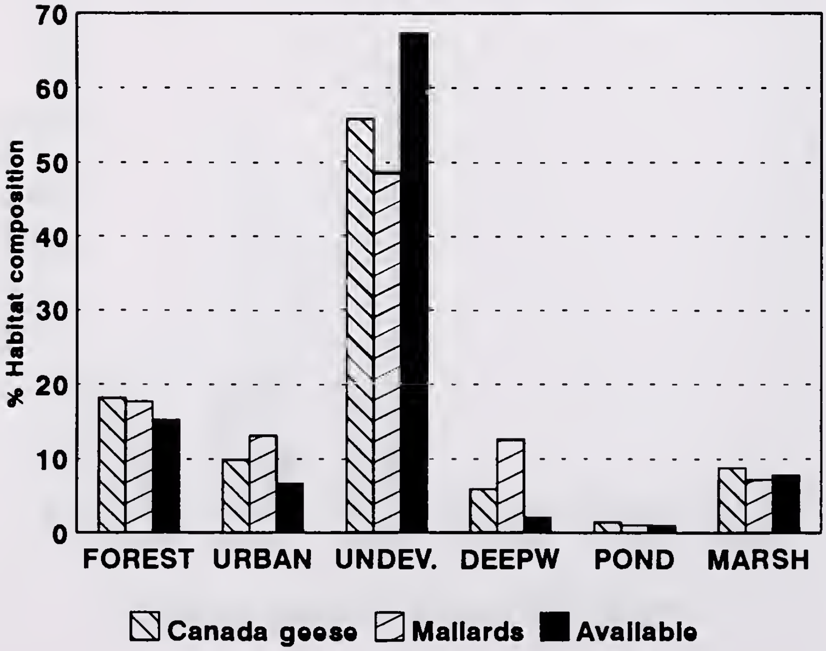
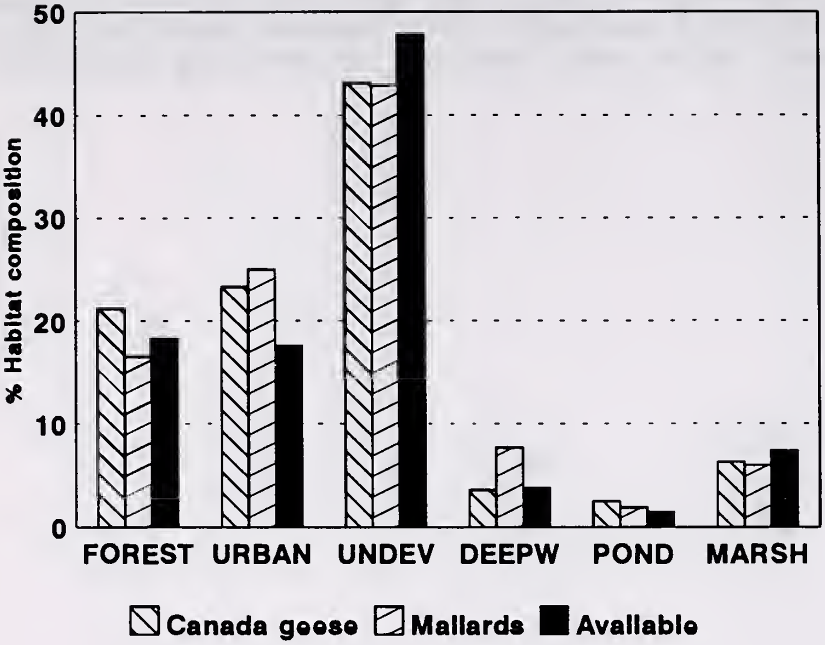


Figure 7. Mean composition of 3 upland and 3 wetland habitats within 1 $km^2$ surrounding locations where flocks of Canada geese and mallards were observed during aerial transect surveys conducted in portions of 5 northeastern Illinois Counties during January and September 1990. Habitat composition surrounding flock locations are compared with habitat availability within areas surveyed, with data from all 5 counties combined.

January 1990



September, 1990

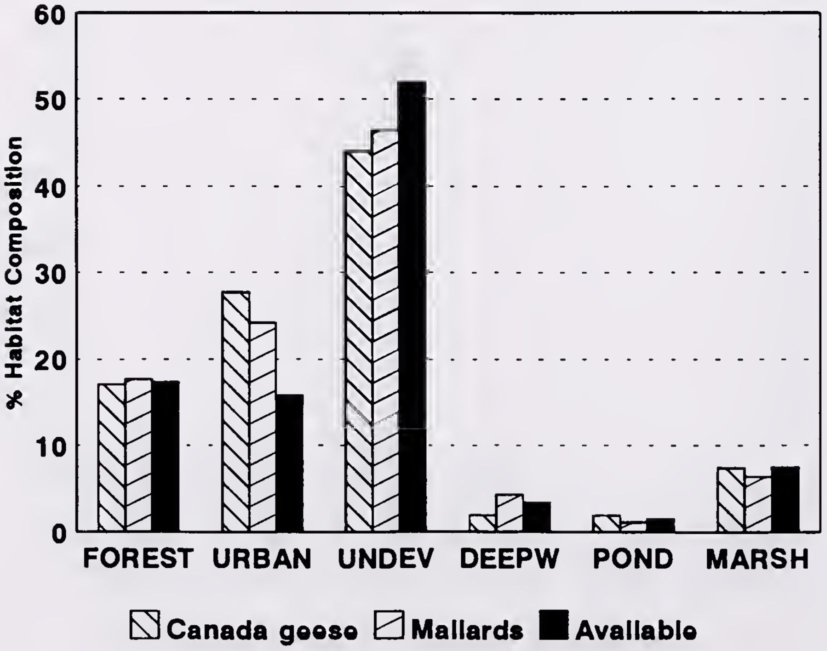
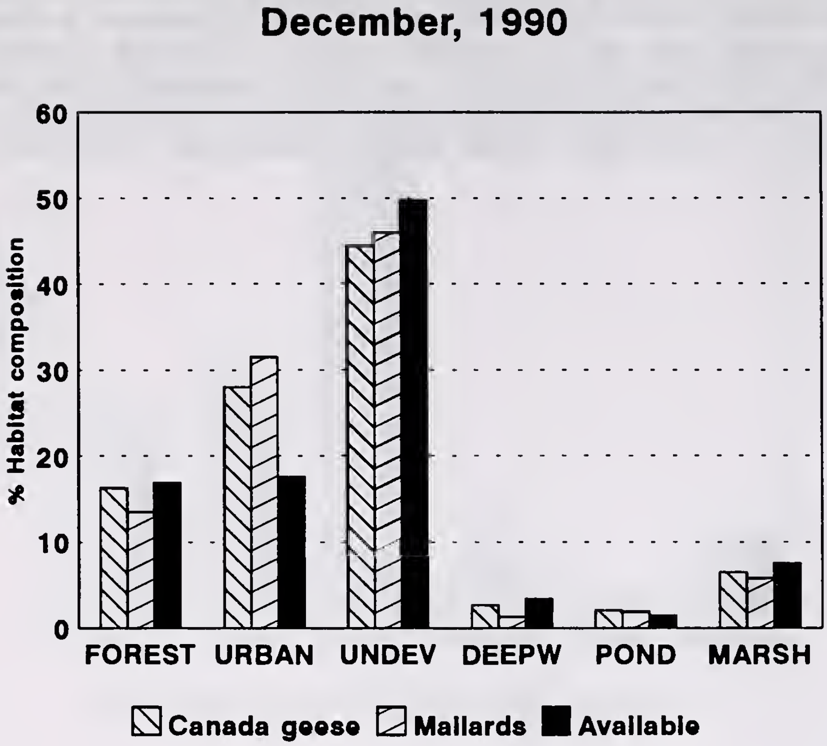
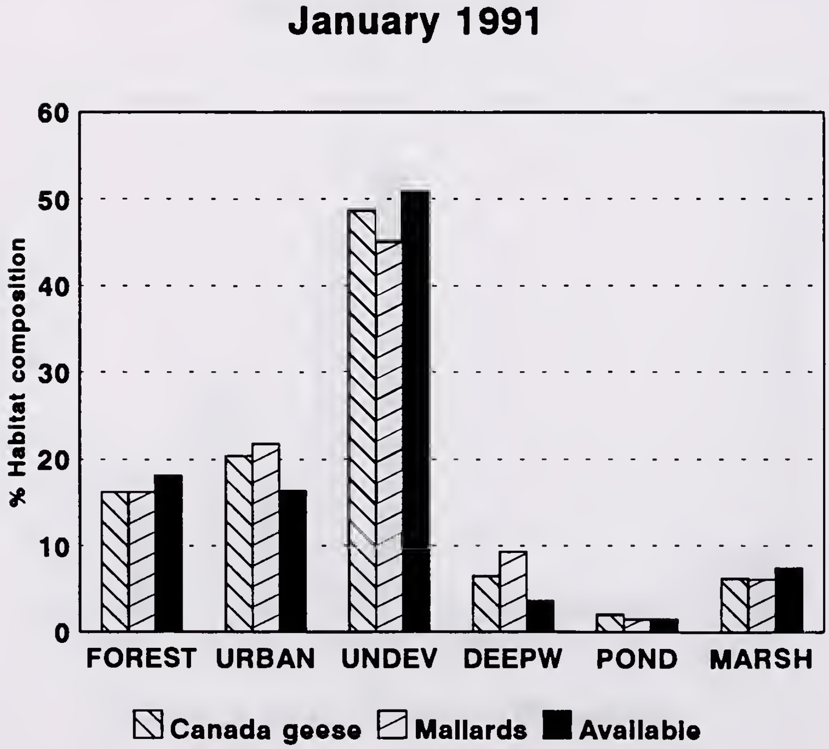


Figure 8. Mean composition of 3 upland and 3 wetland habitats within 1 km$^2$ surrounding locations where flocks of Canada geese and mallards were observed during aerial transect surveys conducted in portions of 5 northeastern Illinois Counties during December 1990 and January 1991. Habitat composition surrounding flock locations are compared with habitat availability within areas surveyed, with data from all 5 counties combined.


December, 1990


January 1991

except the fourth survey when no significant differences were observed (t - test, $P \geq 0.113$) between habitat composition surrounding flock locations and area surveyed, Canada goose and mallard flock locations were surrounded by greater proportions (t - test, $P \leq 0.011$) of urban lands and lower proportions (t - test, $P \leq 0.040$) of undeveloped lands.

Distributions and habitat associations of post-breeding waterfowl as determined from aerial surveys conducted January 1990 through January 1991 demonstrated strong associations with urban areas where refuge was provided from hunting and open water was available during cold weather conditions. Continued growth of urban waterfowl populations (particularly Canada geese) in northeastern Illinois can be expected to result in increased conflict with human interests. The association of waterfowl with urban areas in northeastern Illinois precludes effective population control through legal harvest. Only 14% of 58,661 Canada geese, and 6% of 11,538 mallards observed during aerial surveys over the 2,870 $km^2$ study area were located in areas with no urban development in the surrounding 1-$km^2$. Fifty-one percent of Canada geese, and 46% of mallards occurred in areas with >20% urban development.

We conducted aerial surveys in the portions of Cook and DuPage Counties that have most recently undergone urban development. Expansion of human developments into these areas has created an interspersion of idle / agricultural lands (including forest preserves), small wetlands, and deepwater habitats with urban land uses in these counties. Conversion of natural wetlands to ponds, and creation of cooling ponds and runoff retention basins in recently developed areas provide open water that attracts migrating and wintering waterfowl. Attractiveness of the area may be enhanced by the proximity of idle / agricultural lands that provide food (cereal grains and green forages) for migrating and wintering Canada geese and mallards. No Canada geese or mallards were observed in areas that did not include some undeveloped land within a 1-$km^2$ area.

## BREEDING SEASON

### JOB A. Waterfowl Distribution and Abundance

Objective: To estimate current distribution and abundance of waterfowl in northeastern Illinois during the breeding season.

### JOB B. Habitat Use and Selection

Objective: To document habitat use and selection by waterfowl during the breeding season.

### INTRODUCTION

Northeastern Illinois contains numerous glacial wetlands and lakes in addition to fens, sedge meadows, and true bogs that do not occur elsewhere in Illinois (Schwegman et al. 1984). Much of the area was initially converted to agricultural land use, and there has been substantial loss of wetlands due to drainage. Northwestward expansion of the Chicago metropolitan area has caused continued drainage and filling of wetlands, and conversion of uplands from agricultural to urban land use. Numerous palustrine wetlands previously dominated by natural marsh vegetation have been converted to more open, homogeneous ponds and impoundments with relatively stable water levels that serve as stormwater runoff detention / retention basins in recently developed areas.

Remaining natural habitats are increasingly fragmented as urban developments expand into rural areas. Important wetland / upland habitat complexes are disrupted as relatively small, shallow wetlands are drained filled, and as urban developments encroach to the margins of larger, deeper wetlands that remain. Most of the remaining natural communities are largely protected within state parks, dedicated nature preserves, and county forest preserves. Land acquisition efforts have focused primarily on larger more permanent wetland types, with little consideration given to small shallow wetlands with temporary or seasonal water regimes.

Despite the tremendous land-use changes that have occurred in northeastern Illinois, a relatively high density and diversity of marshes, ponds, and wet prairies remain that provide attractive breeding habitat for waterfowl and other threatened and endangered wetland birds (Heidorn et al. 1991). Breeding bird survey data (R. A. Montgomery, Max McGraw Wildl. Found., pers. commun.), indicates that Canada geese, mallards, wood ducks (Aix sponsa), and blue-winged teal (Anas discors) are relatively abundant breeding waterfowl in northeastern Illinois. The region also provides habitat for waterfowl during fall and spring migration (Havera 1985). Creation of numerous small ponds and impoundments has created attractive habitat for Canada geese in urban areas of northeastern Illinois (Gore 1978). Grass lawns maintained on golf courses and commercial property provide attractive feeding areas in close proximity to open ponds and marshes that provide breeding and brood rearing habitat for geese. However, urban areas that provide refuge from hunting have allowed Canada goose populations to steadily increase to what are increasingly perceived as "nuisance" levels in this region of Illinois.

Only limited data is available on the current population status of breeding waterfowl in northeastern Illinois. J. B. Low (Ill. Nat. Hist. Surv., unpubl. data). surveyed nesting waterfowl on ponds and lakes in northeastern Illinois during 1941-42. S. H. Garland (Ill. Nat. Hist. Surv., unpubl. data) conducted a follow-up study in 1956. More recently, Southern et al. (1981) surveyed waterbird populations on wetlands $\geq$ 2 ha in size. An annual spring survey of threatened and endangered wetland birds on 59 northeastern Illinois wetlands was initiated by the Illinois Department of Conservation (IDOC) in 1980 (Heidorn et al. 1991). Wetlands included in the IDOC survey consisted of those rated as high quality by Southern et al. (1981), wetlands identified in the Illinois Natural Areas Inventory, wetlands located within nature preserves, state parks, or forest preserves, or where threatened and endangered species were previously reported. Although these studies provided useful information about avian populations of northeastern

Illinois wetlands, they did not examine the full array of wetlands available to breeding waterfowl or habitat characteristics associated with wetlands. Previous studies focused primarily on larger wetlands with mostly semi-permanent or permanent water regimes, and/or were conducted outside of the primary breeding seasons of waterfowl inhabiting this portion of the state.

Although North American populations of Canada geese (Branta canadensis) are currently stable or increasing, continental duck populations have declined. In 1955, there were an estimated 10.5 million breeding mallards in the United States and Canada. These estimates declined to an all time low of 5.5 million in 1985 (Reynolds et al. 1990). The mallard population has recently increased to approximately 6 million (Kelly et al. 1989, Reynolds et al. 1990). The U.S. Fish and Wildlife Service forecasts fall flights from breeding pair and brood surveys along aerial transects over primary waterfowl production areas (i.e. Alaska, central Canada, and the prairie pothole / parkland regions of the north-central U. S.) (Bellrose 1980). This information is used to provide estimates of breeding effort and success that are used to establish harvest regulations. However, these surveys do not provide information about scattered local waterfowl populations in areas of secondary importance (Evans and Black 1956). Although these areas support low to moderate densities of breeding waterfowl, they collectively represent a large total area that could contribute substantially to North American waterfowl production.

Small scale ground censuses of breeding waterfowl have been used to provide information about local ecological factors affecting waterfowl production (Diem and Lu 1960, Stewart and Kantrud 1972, Brewster et al. 1976, Ruwaldt et al. 1979, Wheeler and March 1979). These censuses provided local and regional waterfowl population and production estimates and useful data upon which management decisions and habitat acquisition programs have been based.

This section reports the results of a 2-year study investigating the breeding ecology of waterfowl in northeastern Illinois. Specific objectives of the study were to: 1) estimate current distribution and abundance of breeding waterfowl in northeastern Illinois, and 2) determine physical and biotic characteristics of wetlands used by breeding waterfowl in northeastern Illinois.

## STUDY AREA

The study area included 20 United States Geological Survey (USGS) 7.5 minute quadrangle maps, in northeastern Illinois (4 quadrangles west to east, 5 quadrangles north to south) (Fig. 1). The 2,870 $km^2$ area so defined included portions of McHenry, Lake, Kane, DuPage, and Cook counties (Figure 1). This area experienced the most recent glaciation in Illinois and is part of the Morainal Section of the Northeastern Morainal Division of Illinois (Schwegman et al. 1984). Soils in this section were derived from glacial drift rather than loess and were poorly drained (Neely and Heister 1987).

Native plant communities of northeastern Illinois historically included forest, prairie, fen, marsh, sedge meadow, and bog (Schwegman et al. 1984). Wetlands in the study area ranged in size from < 1 ha to > 400 ha and were formed by late advances of the Wisconsinan glaciation (Schwegman 1984, Neely and Heister 1987). Wetlands were located in broad glacial moraines that parallel the shoreline of Lake Michigan. These wetlands are part of the larger wetland complex of the Great Lakes Region (Willman and Frye 1970). Cattails (*Typha* spp.) and bulrushes (*Scirpus* spp.) dominated marshes while dogwoods (*Cornus* spp.), willows (*Salix* spp.), and sedges (*Carex* spp.) dominated sedge meadows.

Approximately 60% of Illinois' human population of 11,430,600 resides in the 5 county area of northeastern Illinois (U.S. Dept. Commerce 1990). The urban human population of the 5 county area has increased dramatically, while rural populations have declined (Gore 1978). The human population has increased by 126,000 since 1980 (Neely and Heister 1987). Gore (1978) found that areas of crop fields decreased in DuPage and Lake counties between 1940-1970, while forested areas increased due to establishment of county forest preserves. Total wetland area in DuPage County increased slightly over this period due to man-made impoundments while Lake County wetland area slightly decreased due to draining and filling of natural wetlands (Gore 1978).

## METHODS

### Upland and Wetland Habitat Classifications

Wetland and upland habitats on the study area were classified using National Wetlands Inventory (NWI) data and satellite imagery from 6 bands (3 visible, 1 near infrared, and 2 mid infrared) of spectral reflectance data collected by the Landsat 5 Thematic Mapper (TM). Wetland (NWI) data were rasterized and merged with satellite imagery creating a composite upland/wetland habitat map and data base. Uplands were broadly classified as urban-developed, forested, and open-undeveloped using Earth Resources Laboratory Application Software (ELAS) (Koeln et al. 1988).

NWI data was based on aerial photography dated 1980-1984, so TM data (dated 11 June, 1988) were used to update wetland changes since NWI (newly expanded, impounded, or excavated ponds). Some wetland habitats were not included on NWI maps but appeared on satellite imagery. Areas with spectral reflectance signatures indicating palustrine open water or ephemeral and temporary emergent habitats were classified as wetlands when located in topographic depressions. Current status of wetland habitats were determined from observations during wetland surveys.

Additional detailed classification of upland habitats was made with satellite imagery using ELAS. Interpretation of spectral data was aided by examining National Aerial Photography Program (NAPP) color infrared (CIR) aerial photographs. Percent composition of upland and wetland habitat types within 1 km of boundaries of surveyed wetland basins was determined using the Map and Image Processing System (MIPS) (Miller et al. 1990).

Several wetland classification systems have been devised for use in various geographic regions (Shaw and Fredine 1956, Stewart and Kantrud 1971, Golet and Larson 1974, and Cowardin et al. 1979). Cowardin (1982) defined problems with wetland classification systems and proposed 2 different concepts of wetland classification. The first was the "area concept" that defines a wetland class as an area of the earth's surface that is homogeneous for a combination of hydrologic, edaphic, and biotic attributes such as those devised by Cowardin et al. (1979) and adopted by NWI. The second was the "physiognomic concept" which defined wetland classes based on entire basins that seldom have homogeneous attributes. A physiognomic classification system devised by Stewart and Kantrud (1971) defined wetland vegetation zones as concentric rings within glacial wetlands and classified entire basins based on the zone occupying the deepest part of the basin. We used a wetland classification system (modified from Stewart and Kantrud 1971) that was physiognomic, but based on NWI designations (Cowardin et al. 1979) under the area concept of wetland habitat classification.

The classification system used in this study was designed to mimic that of Stewart and Kantrud (1971) using the Cowardin et al. (1979) system. According to Cowardin (1982), wetland classification systems based on the area and physiognomic concepts could be integrated with an appropriate set of rules. Wetland basins were defined as physiognomic entities (temporary, seasonal, semipermanent marsh, pond, lake, stream, and river) by classifying wetlands based on relative areas of homogeneous wetland habitats within basins. Under this system it was possible to examine wetland basin use by breeding waterfowl under the physiognomic concept, and to relate wetland basin use by breeding waterfowl to wetland habitats occuring within basins under the area concept.

Wetlands in this study were initially classified according to system, subsystem, class, water regime, and coverage of emergent vegetation as designated by NWI (Cowardin et al. 1979). NWI identified 186 unique wetland habitat types within the 20 quadrangle study area. These wetland habitat types were combined into lacustrine (lake), riverine (river and stream), palustrine natural pond, modified pond (including palustrine unconsolidated bottom, unconsolidated shore, aquatic bed, and open water NWI classes), palustrine wooded (scrub/shrub and forested NWI classes), and palustrine emergent habitats. Palustrine natural and modified pond habitats were separated by NWI special modifiers (diked/impounded or excavated). Palustrine emergents were separated by NWI water regime modifiers into temporary (temporary, saturated, and intermittently flooded/temporary water regimes), seasonal (seasonal, seasonal well drained, seasonal saturated, intermittently flooded, and saturated/semipermanent/seasonal water regimes), and semipermanent (semipermanent, intermittently exposed, and permanent water regimes) wetland habitats.

Wetland basins were classified according to their relative composition of wetland habitats described above. Palustrine basins were defined as groups of adjacent computer image pixels that constituted ponds, temporary, seasonal, and semipermanent marshes. Basins with > 90% of their area designated as palustrine natural and/or modified pond habitat were classified as pond. Basins containing > 90% of a temporary emergent habitat, or any temporary emergent habitat with < 90% pond habitat were classified as temporary marsh. Basins containing ≥ 10% seasonal emergent habitat were classified as seasonal marsh. Wetlands containing ≥ 10% semipermanent emergent habitat or any seasonal emergent habitat with > 10% pond habitat were classified as semipermanent marsh. Semipermanent marshes also included any lacustrine littoral subsystem habitats surrounded by palustrine semipermanent emergent habitats.

Riparian habitats (stream segments) were identified as long (≥ 1.6 km) and linear or curvilinear palustrine habitats and riverine segments. Rivers were classified as any riverine system habitat, and lakes were classified as any lacustrine system habitat not previously classified as palustrine semipermanent marsh.

### Wetland Basin Sampling

Wetlands were selected for ground surveys by randomly selecting 30 sample points within the study area. One to 2 sample points were selected in each 7.5 minute quadrangle map area by random selection of latitude / longitude coordinates. The 2 closest wetlands in each wetland sample stratum (temporary, seasonal, semipermanent marsh, and pond) to each sample point were censused. This provided a sample of 240 basins. Fifty-two alternate basins were selected to replace those that were completely destroyed or radically altered since wetlands were mapped by NWI. Alternate basins were the next closest wetland of the altered type (stratum) to the sample point. Access to 12 basins was denied by landowners. In these instances, the nearest basin of the same type was selected.

Thirteen lakes, 2 semipermanent marshes, and 2 segments of the Fox River were also censused. Censused lakes were selected from a random sample of latitude / longitude points within the study area. The closest lacustrine basin to each sample point was censused. The Fox River was surveyed from Elgin to Carpentersville and from Algonquin to Moraine Hills State Park near McHenry.

Ninety-seven palustrine wetlands and 20 stream segments were added to the 292 wetlands surveyed in 1990. Palustrine wetlands included 45 wetlands randomly selected within forest preserves and state natural areas, (FN basins) and 52 wetlands identified from satellite imagery but not identified by NWI located on (SI basins). FN wetlands were randomly selected from forest preserves and natural areas located on a 1990 Rand McNally Chicago Tribune Chicagoland Map. Two basins, each of 4 types, if present in a preserve were selected. FN basins included 15 semipermanent marshes, 14 seasonal marshes, 5 temporary marshes, and 11 ponds. SI basins included 26 temporary marshes and 26 ponds. The closest SI basins of each type (pond and temporary marsh) within a 163 km$^2$ block surrounding each of the original 30 random sampling points were selected. One stream segment closest to the randomly selected point in each of 20 quadrangle map area was also surveyed.

Three percent (1990) to 4% (1991) of all palustrine wetland basins, 6% of lake basins, and 17% of riverine habitats within the 2,870 km$^2$ study area were surveyed for breeding waterfowl during springs 1990 and 1991. Twenty-two percent of the stream segments in the study area were surveyed in 1991.

### Wetland Surveys

Breeding pair counts were conducted twice from 23 March - 11 May 1990 and 3 times from 1 April - 12 June 1991. Timing of spring breeding pair censuses was designed to correspond with chronologies of pair formation and nesting of the most abundant breeding waterfowl in northeastern Illinois (Wheeler and March 1979, Bellrose 1980, R. Montgomery, Max McGraw Wildl. Found., pers. commun., R. A. Williamson, Ill. Dept. of Cons., pers. commun.). Breeding pair censuses were initiated after peak spring migration of dabbling ducks through northeastern Illinois (Havera 1985). A minimum of 2 breeding pair censuses were necessary to assess the number of pairs in a multispecies breeding population with asynchronous nesting (Dzubin 1969a, Brewster et al. 1976, Ruwaldt et al. 1979, Murphy et al. 1984). The first survey each year targeted early nesting mallard, Canada goose, and wood duck pairs. The second census surveyed late nesting mallard and blue-winged teal pairs and broods of early nesting species. A third survey was added in 1991 to better assess brood production of early nesters and breeding status of blue-winged teal.

All wetlands were walked, waded, or surveyed by boat to determine the number of waterfowl and other wetland birds present (Diem and Lu 1960). Members of 1-3 person teams split and circled palustrine wetlands in opposite directions to flush and record all waterfowl. Dense stands of emergent vegetation were walked while observers made noise to flush concealed birds. Open water areas were scanned with binoculars and/or a 20X spotting scope before entering the wetland. This technique facilitated accurate observation of waterfowl brood sizes. Stream banks were walked by 1 observer. Flushed birds were observed until they resettled or left the area entirely to reduce duplicate counting.

Waterfowl were recorded by species as pairs, mixed sex flocks, single sex flocks, single sex, unknown sex, or unknown species. Mallards on lakes and rivers that appeared to be hybrids with domestic ducks, as determined by plumage coloration and size, were excluded from analysis.

Censuses were conducted from 1/2 hour after sunrise to 1/2 before sunset (Brewster et al. 1976). Because wind, temperature, and precipitation influence spring waterfowl surveys by reducing activity and visibility of pairs, moderate to heavy rain, fog, and other severe weather conditions (i.e., temperatures < 5 C) were avoided (Diem and Lu 1960, Hammond 1969). Surveys were delayed many mornings until sheet ice had melted from shallow wetlands.

Total numbers of indicated breeding pairs/wetland were determined by summing the number of segregated pairs, lone males, and males in groups $\leq$ 4 (Hammond 1969, U.S. Fish and Wildl. Serv. and Can. Wildl. Serv. 1987). Lone females were considered to represent breeding pairs when the number of lone females on a wetland exceeded the number of males unaccompanied by females (Stewart and Kantrud 1972). Total numbers of Canada goose pairs included segregated pairs and singles exhibiting characteristic defense behavior along an area of shoreline (Perkins 1981, Lawrence 1987).

Relatively uncommon and special interest (state threatened or endangered) avian species were recorded during waterfowl surveys along with the location of any nests or offspring.

All waterfowl nests encountered during surveys were examined. Clutch size and incubation status were recorded for each nest visit. Nest material, egg color, and temperature of eggs were used to indicate incubation status. Islands, muskrat (Ondatra zibethicus) lodges, and muskrat feeding platforms were also searched for nests. Nest fates were determined from examination of shell remains at nest sites. Successful nests were defined as $\geq$ 1 egg hatched from a clutch. Nests were marked and numbered with 2.5 x 30.5 cm wooden paint paddles to aid relocation on subsequent visits during 1991.

Canada goose brood sizes were recorded and pooled across gosling age classes. Because the largest observed clutch size was 10 eggs, Canada goose broods > 10 goslings were considered gang broods and were eliminated in comparing calculation of brood sizes. Canada goose clutch and brood sizes, were compared using 2 sample t-tests.

An aerial survey of 2 lakes, 25 semipermanent marshes, 8 seasonal marshes, 6 stream segments, and 1 river segment was attempted on 23 April 1990. The aerial survey was flown at a minimum altitude of 122 m with 2 Bell Jet Ranger (military model OH-58) helicopters each manned with 1 pilot and 1 observer. Three seasonal and 5 semipermanent marshes were censused on the ground within 1 week of aerial censuses to estimate accuracy of air surveys. Due to poor detection of IBPs from helicopter surveys, aerial surveys of breeding waterfowl were not continued.

### Wetland Habitat Characteristics

Seasonally varying characteristics of surveyed wetlands were estimated and recorded during each visit. Vegetation zones (moist soil-shallow emergent, robust emergent, submergent-floating leaf, and open water) within each wetland were identified from the presence of plant species listed in Appendix B. Plant nomenclature and classification followed Fassett (1985) and Mohlenbrock (1986). Proportional area of each vegetation zone that comprised surveyed basins was visually estimated. Percent of each basin with surface water present was recorded during each visit. Cover types (1-4) representing interspersion of emergent vegetation and open water were indexed according to Stewart and Kantrud (1971).

### Invertebrate Sampling

A subsample of palustrine wetlands that were surveyed for breeding pairs was selected to determine the taxonomic diversity and density of aquatic macroinvertebrates within wetland strata. Macroinvertebrates were defined as invertebrates retained by a U.S. Standard No. 35 sieve (0.5 mm mesh) (Murkin and Kadlec 1986). Two sample sites were selected in each vegetation zone present in each wetland. Sample sites were selected in the first vegetation zone encountered on 2 north-south or east-west transects until all available zones present were sampled. Sample sites were located in water < 1 m deep where waterfowl could land and feed (Godin and Joyner 1981, Fredrickson and Taylor 1982).

Invertebrates were sampled with a D-frame aquatic dip net (0.5 mm mesh and 643 $cm^2$) and a substrate core sampler (5.08 cm diameter x 10.16 cm depth). Net sweeps sampled nektonic invertebrates, and the core sampler sampled benthos (Swanson et al. 1974, Swanson 1978). The D-frame net was modified by bending the handle 45 degrees upward from horizontal allowing it to be placed flat on the substrate (Voigts 1976). Nektonic samples were taken by placing the net on the substrate, moving to an undisturbed area, and then raising the net through the water column to the surface in a manner that did not displace organisms in the water column (Voigts 1976, Murkin and Kadlec 1986). The core sampler was modified from Swanson (1978, 1983).

Three net sweeps and 3 core samples were taken at each site. The net sweep and core samples at each site were pooled, yielding 1 net sweep and 1 core sample per site. Therefore, 2 nektonic and 2 benthic samples were taken in each vegetation zone present in each wetland (1 pooled sample x 2 sampling sites). All samples were washed in a U.S. Standard No. 35 sieve to remove excess debris. Net sweep and core samples were placed in individually marked plastic jars and preserved with 10% formalin (Bartonek and Hickey 1969).

Fifteen wetlands were sampled for macroinvertebrates on 15-18 April and 8-10 May, 1990. Due to the difficulty of handling benthic core samples, substrate sampling was eliminated in 1991. Five additional wetlands were sampled for macroinvertebrates in 1991. Thus, a total of 20 wetlands were sampled 26-27 April and 25-26 May, 1991.

Invertebrate samples were cleaned of soil and excess vegetation in a 0.5 mm mesh sieve in the lab. Excess vegetation was examined for invertebrates, rinsed with water, and removed from the sample. Invertebrates were stained with rose bengal for a minimum of 24 hours to facilitate sorting organisms from vegetation (Mason and Yevich 1967). Invertebrates were generally identified to the taxonomic level necessary to determine foraging guild (shredder, scraper, collector, or predator) of the organism (Murkin and Ross 1988). Identification (Pennak 1978, 1989; Merrit and Cummins 1984) was usually to family except for the orders Cladocera and Conchostraca, and subclasses Copepoda and Ostracoda. Higher levels of classification were used for lower invertebrates (e.g. Oligochaeta) (Murkin and Ross 1988). Identified invertebrates were classified to life stage (larvae, pupae, nymph, or adult). A Sedgwick-Rafter counting cell was used to subsample samples that contained > 1,000 organisms (Welch 1948).

## Data Analysis

Waterfowl population estimates.--Population estimates were calculated for the study area based on mean numbers of IBPs and broods observed/wetland in each sample stratum. Mean densities for all species and surveys were weighted by the total numbers of wetlands in each stratum present on the study area to provide a composite estimate of IBP and broods densities per palustrine wetland basin. Confidence intervals (95%) were calculated according to Steel and Torrie 1960:417-420). Weighted mean and 95% confidence interval estimates of IBPs and broods per wetland were extrapolated to the entire study area based on total numbers of palustrine wetland basins. All surveyed wetlands were used to calculate population estimates regardless of actual condition (i.e., drained, dry, filled, or excavated). Therefore, population estimates automatically corrected for wetlands that had been destroyed or altered since NWI.

Wetland Selection.--Mean numbers of IBPs and broods/wetland area was determined for the different wetland types using the MEANS procedure of the Statistical Analysis System (SAS) (SAS Inst. Inc. 1988a). The hypothesis of no wetland type x survey interaction effect, examining relative differences to different wetland types among surveys, was tested using a repeated measures Analysis of Variance (ANOVA) with the GLM procedure of SAS (SAS Inst. Inc. 1988b). Repeated measures ANOVA was also used to detect differential use of wetland types across surveys by IBPs and broods. Tukey/Kramer post hoc multiple comparison tests were used to separate differences in use of wetlands by IBPs and broods.

Wetland habitat selection was examined with waterfowl densities expressed as pairs/wetland area and as pairs/wetland basin. Selection of different wetland types by breeding pairs was tested using chi-square goodness-of-fit and Bonferroni $\underline{z}$ statistics (Neu et al. 1974). When chi-square analysis rejected the null hypothesis that observed wetland use differed from expected, Bonferroni $\underline{z}$ statistics were used to determine whether observed wetland use occurred more or less frequently than expected. Preference for a wetland type was indicated when expected use was < the lower limit of the Bonferroni confidence interval for observed use. Avoidance was indicated when expected use was > the upper Bonferroni confidence interval. Wetland use in proportion to availability occurred when expected use was within the Bonferroni confidence interval of observed use.

Habitat data were analyzed with stepwise multiple regression using forward selection in the STEPWISE procedure of SAS (SAS Inst. Inc. 1988$\underline{b}$). Six independent wetland variables measured from the GIS/wetland data base were analyzed using mean numbers of IBPs or broods observed/wetland/visit as the dependent variable. Independent wetland variables included total wetland area, area of pond, temporary, seasonal, wooded, and semipermanent emergent wetland habitats.

Six seasonally variable wetland habitat variables measured during each visit were analyzed using the number of IBPs or broods observed/wetland visit as the dependent variable. Independent variables included percent of basin with surface water, wetland cover type 1-4 (Stewart and Kantrud 1971), and percent of basins in moist-soil shallow emergent, robust emergent, submergent-floating leaf vegetation, and open water (Table 4). The number of IBPs or broods observed/wetland visit was used as the dependent variable.

Relationships of land use / wetland habitat composition surrounding surveyed wetlands with densities of IBPs and broods observed during surveys were tested using multiple regression. Percent composition of adjacent land

Table 4. Variable list used in regression analyses of waterfowl indicated breeding pair (IBP) and brood densities in wetland habitats in northeastern Illinois.

| Variable Name | Variable Description |
|---|---|
| TOTAL | Total area of all habitats within a wetland |
| POND | Natural and modified pond wetland habitat |
| WOOD | Scrub shrub or forested emergent wetland habitat |
| TEMP | Temporary emergent wetland habitat |
| SEAS | Seasonal emergent wetland habitat |
| SEMI-P | Semi-permanent emergent wetland habitat and lacustrine, littoral, open water surrounded by emergent vegetation[a] |
| LAKE | Lacustrine system habitat[a] |
| RIVER | Riverine system habitat[a] |
| DRYAG | Cultivated upland habitat of more mesic soils as determined by satellite imagery |
| WETAG | Cultivated upland habitat of more hydric soils as determined by satellite imagery |
| OLDFLD | Grassland and primary succession |
| GOLF | Manicured golf course lawn |
| EXCAV | Gravel quarry |
| URBAN | Dense metropolitan area (inner city) |
| RESID | Suburban residential area |
| LAWN | Corporate and residential lawn |
| FOREST | Upland habitat covered with trees |
| WET | Percent of basin with surface water |
| COVER | Cover types (1-4) that estimate vegetation to open water interspersion (Stewart and Kantrud 1971) |
| PERCENTA | Percent of basin in moist soil - shallow emergent vegetation |
| PERCENTB | Percent of basin in robust emergent vegetation |
| PERCENTC | Percent of basin in submergent - floating leaf vegetation |
| PERCENTD | Percent of basin in open water |

[a] Follows classification system of Cowardin et al. (1979)

use / habitat types within 1 km of surveyed basins was regressed on the mean number of IBPs or broods observed/wetland area/visit. Only surveyed wetlands capable of holding water and appearing as represented by the GIS/wetland data base were used in regression analyses. On a larger scale, stepwise regression was used on to relate mean numbers of IBPs/wetland area/quadrangle/visit to percent composition of upland, wetland, and deepwater habitats in each of the 20 quadrangle map areas. All classified habitats were used as independent variables in regression models (Table 4).

Invertebrate Abundance.--The GLM procedure of SAS (SAS Inst., Inc. 1988b) followed by Tukey/Kramer post hoc multiple comparison tests were used to compare benthic core samples collected during the first and second invertebrate sampling periods. Post hoc tests compared nektonic net sweep samples collected during invertebrate sampling periods 1-4, respectively. Dependent variables were the number of taxa/l and number of organisms/l. When computing the number of taxa/l, all life forms of a specific taxa were combined, and all unknown classifications were excluded (Appendices C-H). The number of organisms and taxa/sample were analyzed by sample type (benthic core or nektonic net sweep), survey period, basin type (temporary, seasonal, semipermanent marsh, or pond), vegetation type (vegetated or open water), and vegetation zone (moist-soil shallow emergent, robust emergent, submergent-floating leaf, or open water). All statistical tests were considered significant at $P \leq 0.05$.

Other Wetland Birds.--Observations of bird species other than waterfowl were summarized by survey period and wetland type (Appendices I-M). Scientific names of these species are presented in Appendix N. Only relatively uncommon and state threatened or endangered species were recorded. Observations represented the presence or absence of these species in a wetland rather than actual densities observed because wetland surveys were not designed to target these species.

## RESULTS

### Habitat Availability

Study Area.--Eighteen habitats were identified in the 2,870 km$^2$ study area. Nine upland habitats totaled 2,526 km$^2$, and 9 wetland habitats totaled 343 km$^2$ (12.0%) (Table 5). The most abundant upland habitat was dry agriculture comprising 41.2% of upland habitats and 36.3% of the study area. Seasonal emergent was the most abundant (31.5%) wetland habitat and totaled 3.8% of the study area.

A total of 9,507 palustrine wetland basins averaging 2.4 ha/basin was identified in the study area with a density of approximately 3.3 palustrine basins/km$^2$ of land area (Table 6). Seasonal marshes were the most abundant wetland type; however, semipermanent marshes comprised the largest wetland basin area.

Surveyed Basins.--Except for open ponds, habitat composition of surveyed wetlands was more diverse as water permanency increased (Figures 9 and 10). Seasonal and semipermanent emergent wetland habitat types were the dominant habitats of semipermanent marshes. Seasonal and temporary marsh strata were largely composed of seasonal and temporary emergent habitat types, respectively. Open ponds were almost entirely composed of 2 pond habitat types (natural and modified). Streams were mostly composed of seasonal and wooded emergent habitat types.

### Wetland Status

A total of 408 wetlands was surveyed, including 95 temporary marshes, 85 seasonal marshes, 98 semipermanent marshes, 102 ponds, and 28 stream segments. Changes were apparent in some wetlands when compared to NWI (Table 7). As of June 1991, 41% of wetland basins had been hydrologically altered or misclassified, including 83% of temporary, 46% of seasonal, 34% of semipermanent marshes, and 15% of ponds. Two temporary marshes, 2

Table 5. Total areas of 9 upland and 9 wetland and deepwater habitat categories in northeastern Illinois.

| Habitat | Area(km$^2$) |
|---|---|
| Upland Habitats | |
| Dry agriculture | 1,041.2 |
| Residential | 438.0 |
| Idle/old field | 300.8 |
| Lawn | 246.3 |
| Wet agriculture | 205.8 |
| Forest | 153.8 |
| Urban | 87.4 |
| Golf course | 28.0 |
| Excavated (gravel quarry) | 25.0 |
| Total upland | 2,526.3 |
| Wetland Habitats | |
| Seasonal emergent | 108.1 |
| Lake | 68.4 |
| Semipermanent emergent | 43.4 |
| Temporary emergent | 35.3 |
| Modified pond | 28.8 |
| Wooded emergent | 28.7 |
| River | 12.2 |
| Natural pond | 9.7 |
| Open water | 8.6 |
| Total wetland | 343.2 |
| Total area | 2,869.5 |

Table 6. Number and size distribution (ha) of wetlands and deepwater habitats located in northeastern Illinois.

| Basin Type | No. of Basins | Area of Basins | Mean Size | % of Basins | % Basin Area |
|---|---|---|---|---|---|
| Semipermanent marsh | 1,300 | 10,602.1 | 8.7 | 13.2 | 31.6 |
| Seasonal marsh | 3,811 | 8,622.3 | 2.3 | 38.7 | 25.7 |
| Temporary marsh | 1,207 | 1,686.4 | 1.4 | 12.3 | 5.0 |
| Pond | 3,189 | 2,357.6 | 0.7 | 32.4 | 7.0 |
| Lake | 211 | 6,931.3 | 32.9 | 2.1 | 20.7 |
| River | - | 1,078.0 | - | - | 3.2 |
| Stream segment | 130 | 2,270.0 | 17.5 | 1.3 | 6.8 |

Table 7. Northeastern Illinois wetland status, 25 May - 12 June 1991, compared to wetlands identified from National Wetlands Inventory (NWI) and satellite imagery.

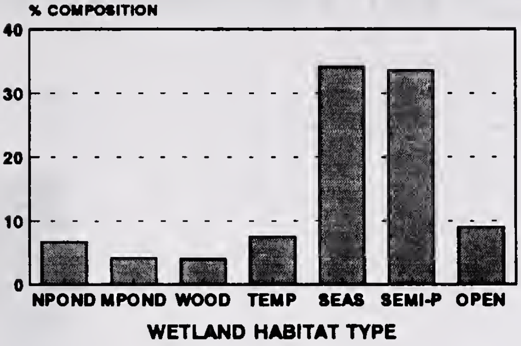
| Wetland Status | Temporary Marsh | Seasonal Marsh | Semi-permanent Marsh | Pond | Stream | Total |
|---|---|---|---|---|---|---|
| Destroyed | 5 | 4 | 2 | 4 | 0 | 15 |
| Excavated | 4 | 4 | 11 | 0 | 0 | 19 |
| Drained[a] | 14 | 22 | 16 | 0 | 0 | 52 |
| Farmed | 10 | 1 | 0 | 0 | 0 | 11 |
| Pastured | 1 | 0 | 0 | 0 | 0 | 1 |
| Drained and farmed | 37 | 3 | 1 | 0 | 0 | 41 |
| Drained and pastured | 4 | 1 | 1 | 0 | 0 | 6 |
| Misclassified | 2 | 0 | 2 | 10 | 0 | 14 |
| Mowed | 0 | 1 | 0 | 0 | 0 | 1 |
| Detention | 2 | 3 | 0 | 1 | 0 | 6 |
| Total altered | 79 (83%) | 39 (46%) | 33 (34%) | 15 (15%) | 0 (0%) | 166 (41%) |
| Total intact[b] | 16 (17%) | 46 (54%) | 65 (66%) | 87 (85%) | 28 (100%) | 242 (59%) |
| Total | 95 | 85 | 98 | 102 | 28 | 408 |

[a] Hydrologically altered basins were tiled and/or ditched.

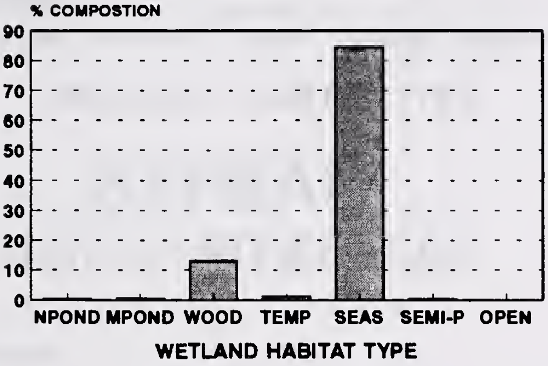
[b] No evidence of human modification.

Figure 9. Wetland habitat composition of marsh basins surveyed for breeding waterfowl during springs 1990-91 in northeastern Illinois. NPOND = natural pond, MPOND = modified pond, WOOD = wooded emergent, TEMP = temporary emergent, SEAS = seasonal emergent, SEMI-P = semipermanent emergent, and open = lacustrine open water.

### SEMI-PERMANENT MARSH
NWI HABITAT 1991



### SEASONAL MARSH
NWI HABITAT 1991



### TEMPORARY MARSH
NWI HABITAT 1991

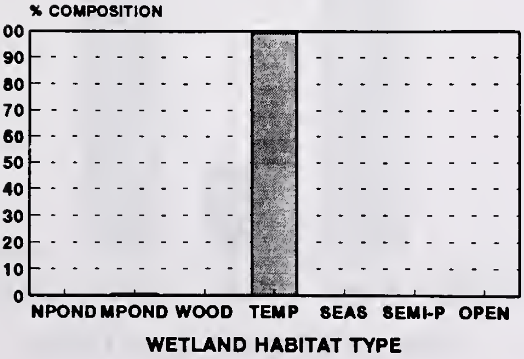
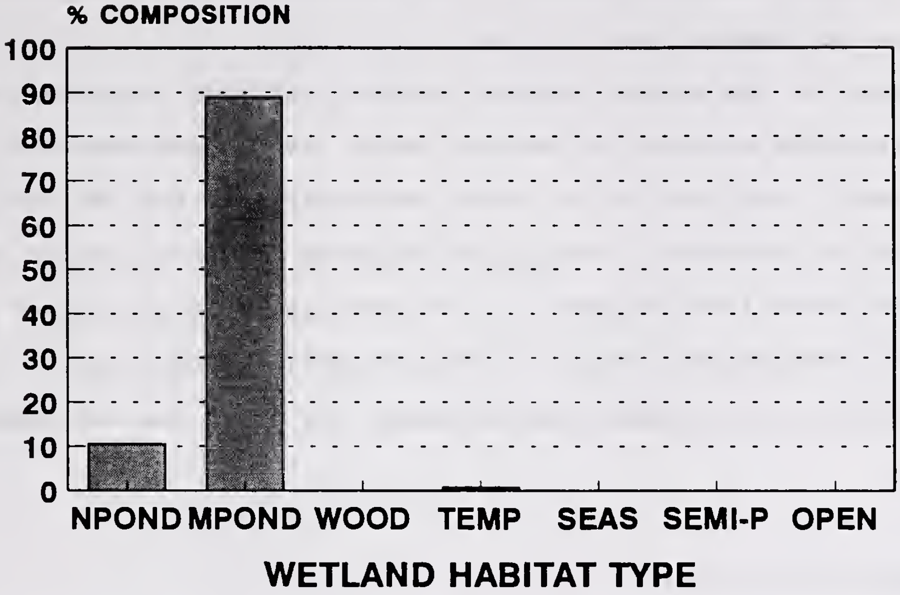
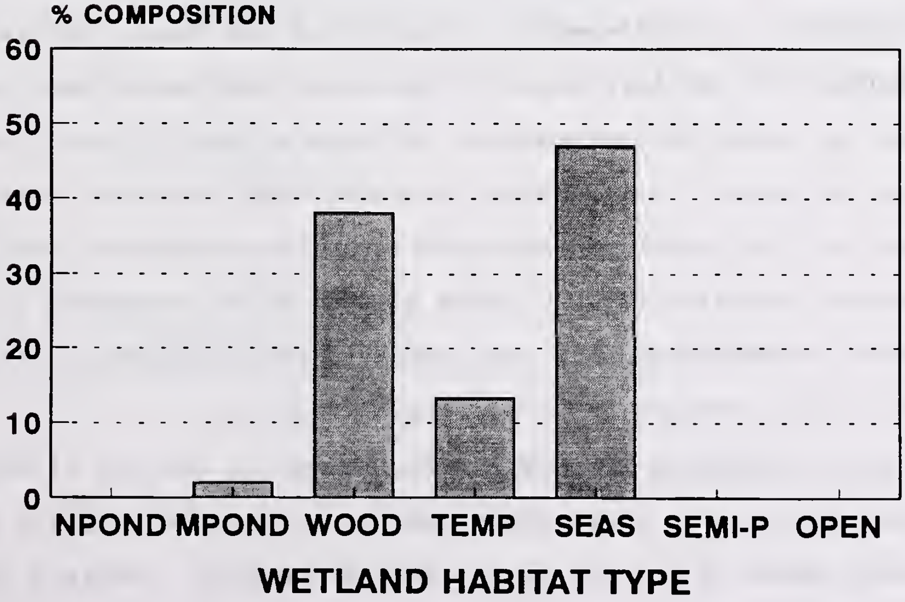


Figure 10. Wetland habitat composition of open ponds and streams surveyed for breeding waterfowl during springs 1990-91 in northeastern Illinois. NPOND = natural pond, MPOND = modified pond, WOOD = wooded emergent, TEMP = temporary emergent, SEAS = seasonal emergent, SEMI-P = semipermanent emergent, and open = lacustrine open water.



**OPEN POND**

**NWI HABITAT 1991**



**STREAM**

**NWI HABITAT 1991**

semipermanent marshes, and 1 pond were apparently misclassified by NWI. The 2 temporary marshes were located adjacent to major roadways that may have altered the water regimes. Nine wetlands (34%) initially identified as ponds from satellite imagery were reclassified after field inspection as 3 seasonal marshes and 1 farmed temporary marsh. The remaining 5 basins were determined to be roof tops and asphalt parking lots.

Four percent of 408 wetland basins surveyed had been completely destroyed since NWI. A minimum estimate of wetland basin loss in northeastern Illinois was 0.4% per year. Availability of water was determined for 264 wetlands surveyed during all censuses. Study area wetlands containing water were more abundant in 1991 than 1990 (Figure 11). An average of 75 and 83% of the 264 wetlands were inundated with water in 1990 and 1991, respectively. Average inundated wetland area increased approximately 100 ha on the 264 basins during 1991 censuses.

## Waterfowl Population Surveys

Twenty-one waterfowl species were observed during spring surveys of northeastern Illinois wetlands. Considering total numbers of birds, Canada geese were the most abundant waterfowl during spring in northeastern Illinois, with mallards second. Seventeen of 21 species were migrants. Mute swans were fairly common breeders in northeastern Illinois but are feral (Bellrose 1980) Considerable numbers of northern shoveler pairs and lone males were observed, but few apparently nested in northeastern Illinois as only 1 brood was observed during the study. Few northern pintails were observed; however, 1 female was observed that exhibited characteristic brood defense behavior indicating northern pintails may be a rare breeder in northeastern Illinois. Three lone female hooded mergansers were observed after migration indicating they may also be rare breeders in northeastern Illinois.

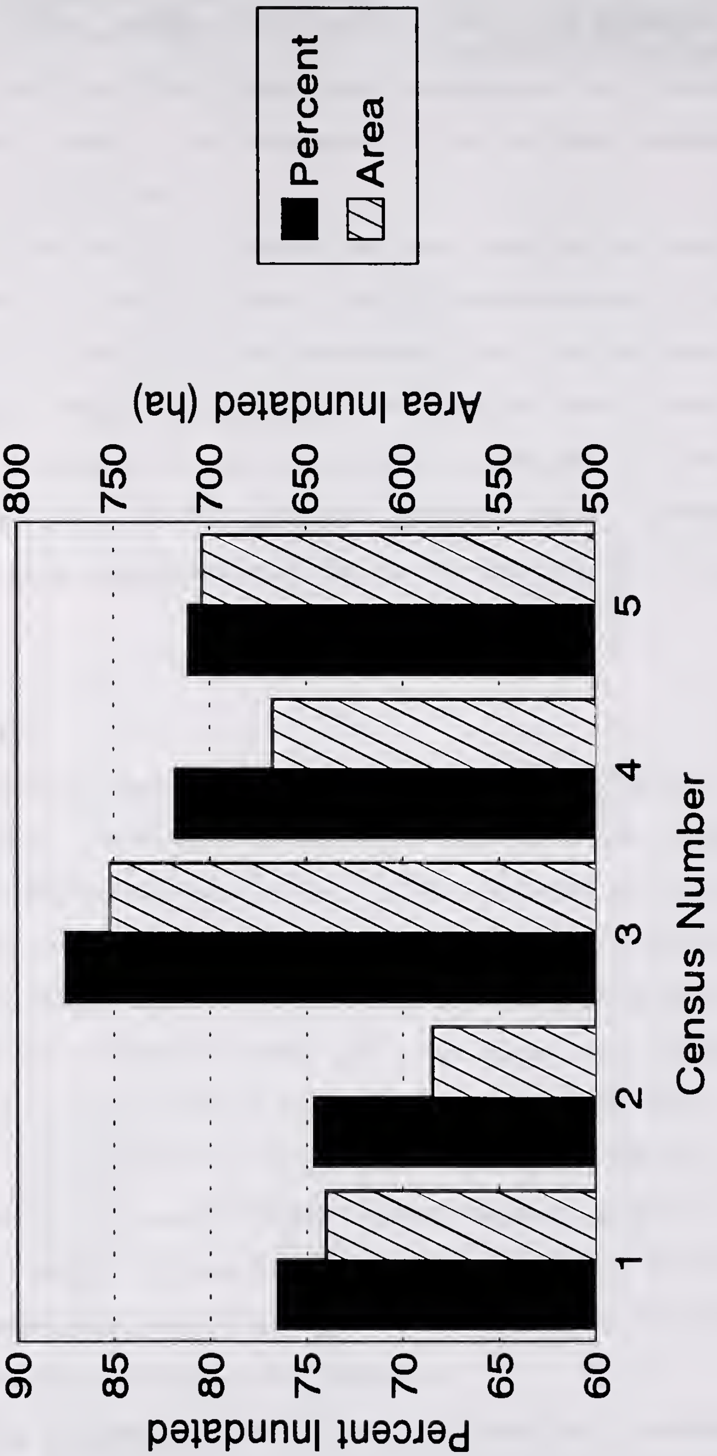
Breeding Pair Population Estimates.--The number of IBPs/ha of wetland differed between surveys for blue-winged teal ($F$ = 3.06, df = 4,940, $P$ = 0.016) and Canada geese ($F$ = 4.01, df = 4,940, $P$ = 0.003). Mallard ($F$ = 1.27,

Figure 11. Availabillity of surface water on 264 wetlands surveyed 23 March - 10 April 1990 (census 1), 18 April - 8 May 1990, (census 2), 1-18 April 1991, (census 3), 27 April - 17 May 1991 (census 4), and 25 May - 12 June 1991 (census 5) in northeastern Illinois.

## Water Availability

### Wetlands Inundated

### N = 264



df = 4,940, P = 0.282) and wood duck (F = 1.92, df = 4,940, P = 0.104) IBP densities did not differ between wetland surveys. Migrant blue-winged teal were observed during early spring, elevating IBP densities in early surveys. Early nesting Canada goose pairs were observed during the first survey each spring, and late nesters were not detected during these surveys.

The chronology of spring migration was indicated by flock characteristics. Large numbers of mixed sex flocks indicated passage of migrant birds, while pairs and lone males indicated prenesting and incubation. Examination of the mean number of IBPs/wetland (Table 8) and the number of waterfowl observed in mixed sex flocks (Appendices O-X) indicated the surveys that provided the best breeding population estimates.

The first census (23 March - 10 April 1990) was too early to survey blue-winged teal populations because most had not arrived from wintering grounds. The second (18 April - 8 May 1990), third (1-18 April 1991), and fourth censuses (27 April - 17 May 1991) produced similar population estimates, but the numbers of birds in mixed sex flocks (Appendix P-R) indicated passage of migrant teal. Therefore, these censuses were excluded from population estimates although resident pairs may have been present. The fifth census (25 May - 12 June 1991) was considered the best indicator of breeding blue-winged teal populations in northeastern Illinois.

The first census (23 March - 10 April 1990) was initiated before incubation by Canada geese and probably underestimated the breeding population. Low IBP densities were observed in the fifth census (25 May - 12 June 1991) because adults with broods had departed nest sites and were not easily observed. The second (18 April - 8 May 1990), third (1-18 April 1991), and fourth censuses (27 April - 17 May 1991) provided the best estimates of the Canada goose breeding population in northeastern Illinois. The second, third, and fourth population estimates were averaged to estimate Canada goose IBP densities.

Table 8. Mean numbers of indicated breeding pairs (IBPs)/wetland and breeding pair population estimates for the study area with 95% confidence limits for 4 species of waterfowl observed 23 March - 10 April 1990 (Census 1), 18 April - 8 May 1990 (Census 2), 1-18 April 1991 (Census 3), 27 April - 17 May 1991 (Census 4), and 25 May - 12 June 1991 (Census 5) in northeastern Illinois.

| Species | Census Number | Mean Pairs/wetland | Confidence Interval | Population Estimate | Upper 95% limit | Lower 95% limit |
|---|---|---|---|---|---|---|
| Blue-winged teal | 1 | 0.04 | (0.01-0.07) | 417 | 704 | 131 |
| | 2 | 0.29 | (0.18-0.40) | 2,778 | 3,818 | 1,739 |
| | 3 | 0.26 | (0.15-0.38) | 2,545 | 3,657 | 1,433 |
| | 4 | 0.25 | (0.16-0.34) | 2,402 | 3,280 | 1,523 |
| | 5 | 0.12 | (0.06-0.18) | 1,154 | 1,695 | 614 |
| Canada goose | 1 | 0.11 | (0.06-0.16) | 1,085 | 1,548 | 622 |
| | 2 | 0.20 | (0.13-0.27) | 1,931 | 2,594 | 1,268 |
| | 3 | 0.32 | (0.21-0.43) | 3,063 | 4,112 | 2,014 |
| | 4 | 0.25 | (0.17-0.34) | 2,435 | 3,286 | 1,584 |
| | 5 | 0.11 | (0.06-0.16) | 1,083 | 1,576 | 590 |
| Mallard | 1 | 1.44 | (0.79-2.08) | 13,818 | 20,009 | 7,628 |
| | 2 | 1.10 | (0.70-1.50) | 10,567 | 14,412 | 6,722 |
| | 3 | 1.08 | (0.84-1.33) | 10,409 | 12,768 | 8,049 |
| | 4 | 0.84 | (0.64-1.04) | 8,109 | 10,045 | 6,172 |
| | 5 | 0.82 | (0.54-1.11) | 7,938 | 10,692 | 5,184 |
| Wood duck | 1 | 0.28 | (0.15-0.41) | 2,724 | 3,970 | 1,479 |
| | 2 | 0.30 | (0.19-0.42) | 2,925 | 4,008 | 1,842 |
| | 3 | 0.24 | (0.14-0.33) | 2,296 | 3,203 | 1,389 |
| | 4 | 0.21 | (0.14-0.28) | 1,986 | 2,672 | 1,299 |
| | 5 | 0.25 | (0.12-0.38) | 2,431 | 3,698 | 1,164 |

Large numbers of mallards were observed in mixed sex flocks during the first census (23 March - 10 April 1990) (Appendix O), indicating passage of migrants. Numbers of lone males decreased in the fifth census (25 May - 12 June 1991) (Appendix S) indicating departure of males on molt migration (Oring 1964, Bellrose 1980, McKinney 1986), thereby reducing the number of IBPs observed. The second (18 April - 8 May 1990), third (1-18 April 1991), and fourth censuses (27 April - 17 May 1991) most accurately reflected mallard breeding populations in northeastern Illinois. These 3 population estimates were averaged to determine mallard IBP densities. Mean densities of wood duck pairs remained relatively stable over all 5 censuses (Table 8). Therefore, all censuses were averaged to determine wood duck IBP densities.

The estimated breeding waterfowl population on palustrine wetlands of northeastern Illinois averaged 15,800 pairs during 1990 and 1991 (Table 8). Total population density on palustrine wetlands was 5.50 IBPs/km$^2$ of total land area. Mallards were the most abundant breeders with 9,695 IBPs and a mean density of 3.38 IBPs/km$^2$. Mallard population estimates were followed in decreasing order by Canada geese (2,476 IBPs, 0.86 IBPs/km$^2$), wood ducks (2,472 IBPs, 0.86 IBPs/km$^2$), and blue-winged teal (1,154 IBPs, 0.40 IBPs/km$^2$).

Estimated mallard pair densities on lakes were (mean ± 95% C.I) 1,397 ± 504 IBPs in the second census, 1,023 ± 641 IBPs in the third census, and 1,974 ± 757 IBPs in the fourth census. Canada goose pair pair population estimates on lakes were (mean ± 95% C.I) 650 ± 608 IBPs in the second census, 730 ± 749 IBPs in the third census, and 795 ± 881 IBPs in the fourth census. Averaging these estimates, lakes contributed an additional 1,213 mallard pairs, and 725 Canada goose pairs to the estimated breeding population of the study area. Wood duck and blue-winged teal pair densities were very low, averaging <0.3 IBP/lake. Consequently, lakes contributed <75 pairs of these species to the total breeding population. Surveyed portions of the Fox River contributed an additional 136 mallard pairs and less than twenty pairs of the other 3 species. Summing breeding pair population estimates for palustrine wetlands, lakes, and only that portion of the Fox River that was surveyed, the total estimated breeding waterfowl population on the study area was 17,949 total pairs (6.25/km$^2$) consisting of 11,044 mallard pairs (3.85/km$^2$), 3,217 Canada goose pairs (1.12/km$^2$), 2,534 wood duck pairs (0.88/km$^2$), and 1,154 blue-winged teal pairs (0.40/km$^2$).

Brood Population Estimates.--The mean number of waterfowl broods observed per wetland varied between surveys. However, because the chronology of nesting affected the mean hatching date of waterfowl nests, only those surveys conducted after peak of hatch were considered.

Peak hatching date of giant Canada goose nests in west-central Illinois over a 5 year period was the first week of May (Perkins 1981, Lawrence 1987). Therefore, the fourth (27 April - 17 May 1991) and fifth censuses (25 May - 12 June 1991) were averaged to estimate Canada goose brood densities. According to Wheeler and March (1979), < 20% of mallard broods in east-central Wisconsin hatched before the third week of May in 1973-1975. Based on these data, the most reliable population estimate for mallard broods was the fifth census (25 May - 12 June 1991). Wheeler and March (1979) also reported the earliest hatching date for wood duck broods to be the fourth week of May; therefore, the fifth census (25 May - 12 June 1991) provided the only reliable estimate of wood duck brood densities.

The population estimate of waterfowl broods on palustrine wetlands of northeastern Illinois was 2,097 with an estimated density of 0.73 broods/km$^2$ of total land area (Table 9). Canada goose broods were the most abundant with a population estimate of 1,250 broods and a density of 0.44 broods/km$^2$. Canada goose brood population estimates were followed in decreasing order by mallards (723 broods, 0.25 broods/km$^2$) and wood ducks (124 broods, 0.04 broods/km$^2$) No waterfowl broods were observed during the first survey of each spring, and no blue-winged teal broods were observed during any spring surveys.

Table 9. Mean numbers of broods/wetland and brood population estimates for the study area with 95% confidence limits for 3 species of waterfowl observed 18 April - 8 May 1990 (Census 2), 27 April - 17 May 1991 (Census 4), and 25 May - 12 June 1991 (Census 5) in northeastern Illinois.

| Species | Census Number | Mean Broods/wetland | Confidence Interval | Population Estimate | Upper 95% limit | Lower 95% limit |
|---|---|---|---|---|---|---|
| Canada goose | 2 | 0.04 | (0.02-0.070) | 421 | 676 | 167 |
| | 4 | 0.16 | (0.09-0.218) | 1,495 | 2,100 | 890 |
| | 5 | 0.10 | (0.06-0.152) | 1,004 | 1,467 | 541 |
| Mallard | 2 | 0.02 | (-0.02-0.045) | 145 | 429 | 0 |
| | 4 | 0.02 | (0.00-0.029) | 147 | 278 | 16 |
| | 5 | 0.08 | (0.04-0.113) | 723 | 1,090 | 356 |
| Wood duck | 2 | 0.01 | (-0.01-0.016) | 50 | 149 | 0 |
| | 4 | 0.00 | (0.00-0.000) | 0 | 0 | 0 |
| | 5 | 0.01 | (0.00-0.025) | 124 | 238 | 11 |

## Canada Goose Nesting Data

Three hundred sixty-one Canada goose nests were located in all 5 surveys (Table 10). Incubated clutch sizes were determined from 129 nests in 1990 and 225 nests in 1991. Clutch sizes averaged 5.4 (SE = 0.07) eggs/nest and did not differ between years ($\underline{P} > 0.05$). Nest success was determined for 20 of 129 nests (16%) in 1990. Nest monitoring efforts were intensified in 1991, and fates of 178 of 232 nests were determined. One hundred thirty-one of 178 (73.6%) nests with known fate hatched successfully.

A total of 290 Canada goose broods were observed during springs 1990-91, (Table 10). Mean brood size was 4.9 (S.E. = 0.1) goslings/brood and did not differ between years ($\underline{P} > 0.05$). Mean clutch and brood sizes of Canada geese differed ($\underline{P} \leq 0.05$) indicating an apparent combined egg infertility, embryo mortality, and early gosling mortality rate of 9.3%. However, brood sizes larger than 10 goslings were excluded from analysis and total brood loss was not accounted for.

Seventy-one waterfowl broods were observed on 24 northeastern Illinois wetlands during July 1990. Canada goose broods were easily observed so mean brood size reported in Table 10 was considered accurate. However duck broods were difficult to count in emergent vegetation and brood sizes reported in Table 10 underestimated actual duck brood sizes.

## Wetland Use

Wetland IBP Densities.-- Relative use by waterfowl of the 4 wetland basin types did not vary between surveys. Nonsignificant interactions of wetland basin type with survey number for blue-winged teal ($\underline{F} = 1.03$, df = 12,940, $\underline{P} = 0.417$), Canada geese ($\underline{F} = 1.26$, df = 12,940, $\underline{P} = 0.234$), mallards ($\underline{F} = 0.45$, df = 12,940, $\underline{P} = 0.945$), and wood ducks ($\underline{F} = 0.77$, df = 12,940, $\underline{P} = 0.679$) justified pooling of pair data from different surveys and years for analysis of wetland selection.

Table 10. Mean incubated clutch and brood sizes (standard error) of Canada geese and mallards in northeastern Illinois observed during springs 1990-91.

| Species | Year | Mean (SE) | Sample size |
|---|---|---|---|
| Clutch size | | | |
| | 1990 | 5.5 (0.1) | n = 129 |
| Canada goose | 1991 | 5.3 (0.1) | n = 225 |
| | Total | 5.4 (0.1) | n = 354 |
| | 1990 | 8.0 (1.0) | n = 2 |
| Mallard | 1991 | 7.9 (0.9) | n = 15 |
| | Total | 7.9 (0.8) | n = 17 |
| Brood size | | | |
| | 1990 | 5.0 (0.2) | n = 55 |
| Canada goose | 1991 | 4.9 (0.1) | n = 235 |
| | Total | 4.9 (0.1) | n = 290 |
| | 1990 | 8.2 (1.7) | n = 5 |
| Mallard | 1991 | 6.6 (0.5) | n = 67 |
| | Total | 6.8 (0.5) | n = 72 |

Canada goose ($F = 5.49$, df = 3,235, $P = 0.001$) and mallard ($F = 6.27$, df = 3,235, $P < 0.001$) IBPs/wetland area differed between basin types; however, densities of blue-winged teal ($F = 0.70$, df = 3,235, $P = 0.551$) and wood ducks ($F = 2.09$, df = 3,235, $P = 0.102$) did not differ between basin types. Canada goose IBP density was greater on ponds than on seasonal and temporary marshes (Table 11). Mallard IBP density was also greater on ponds than on seasonal and semipermanent marshes. Unlike geese, mallard IBP densities on ponds were not greater than on temporary marshes.

*Brood Densities*.--There was no interaction between survey and basin type for mallard ($F = 1.16$, df = 12,940, $P = 0.311$) and wood duck ($F = 0.98$, df = 12,940, $P = 0.468$) broods. A significant interaction ($F = 2.60$, df = 12,940, $P = 0.002$) between survey and basin type for Canada goose broods indicated that densities varied among basin types between surveys.

Canada goose brood densities differed among basin types ($F = 3.99$, df = 3,235, $P = 0.009$) (Table 12). Mallard ($F = 1.84$, df = 3,235, $P = 0.140$) and wood duck ($F = 0.95$, df = 3,235, $P = 0.416$) brood densities did not differ among basin types.

Canada goose brood densities were greatest on ponds for all 3 surveys in which broods were encountered (Table 12). ANOVA produced significant F values for Canada goose brood densities in the fourth ($F = 3.43$, df = 3,235, $P = 0.018$) and fifth ($F = 2.84$, df = 3,235, $P = 0.039$) surveys; however, post hoc comparisons detected significant differences only in the fourth survey. Canada goose brood densities during the fourth survey were greater on ponds than on temporary marshes.

*Forest preserve vs. private wetlands*.--IBP densities (mean IBPs/wetland area/visit) were compared between wetlands on public vs. private lands in 1991. Densities of blue-winged teal were greater ($F = 7.41$, df = 1,378, $P = 0.007$) on forest preserves and state natural areas than wetlands in private ownership. Mean densities of Canada geese ($F = 1.90$, df = 1,378, $P = 0.169$),

Table 11. Mean (standard deviation) numbers of waterfowl indicated breeding pairs (IBPs)/ wetland area (ha) observed on temporary, seasonal, and semipermanent marshes, and ponds during springs 1990-19 in northeastern Illinois. Row means not sharing the same letter were statistically different ($\underline{P} \leq 0.05$, Tukey/Kramer tests).

| | Wetland type | | | |
|---|---|---|---|---|
| Species | Temporary Marsh (n=55) | Seasonal Marsh (n=61) | Semi-permanent Marsh (n=62) | Pond (n=61) |
| Blue-winged teal | 0.12 (0.40)a | 0.10 (0.28)a | 0.07 (0.29)a | 0.17 (0.52)a |
| Canada goose | <0.01 (0.01)b | 0.04 (0.14)b | 0.14 (0.31)ab | 0.22 (0.54)a |
| Mallard | 0.84 (2.38)ab | 0.49 (0.81)b | 0.46 (0.65)b | 1.52 (1.76)a |
| Wood duck | 0.05 (0.28)a | 0.19 (0.58)a | 0.19 (0.47)a | 0.38 (1.13)a |

Table 12. Mean (standard deviation) numbers of waterfowl broods/wetland area (ha) observed on temporary, seasonal, and semipermanent marshes, and ponds 18 April - 8 May 1990 (Census 2), 27 April - 17 May 1991 (Census 4), and 25 May - 12 June 1991 (Census 5) in northeastern Illinois. Row means not sharing the same letter were statistically different ($\underline{P} \leq 0.05$, Tukey/Kramer tests).

| Census Number | Species | Wetland type<br>Temporary Marsh (n=55) | <br>Seasonal Marsh (n=61) | <br>Semi-permanent Marsh (n=62) | <br>Pond (n=61) |
|---|---|---|---|---|---|
| 2 | Canada goose | 0.00 (0.00)a | 0.03 (0.21)a | 0.03 (0.12)a | 0.09 (0.47)a |
|  | Mallard | 0.00 (0.00)a | 0.00 (0.00)a | 0.00 (0.00)a | 0.01 (0.12)a |
|  | Wood duck | 0.00 (0.00)a | 0.02 (0.16)a | 0.00 (0.00)a | 0.00 (0.00)a |
| 4 | Canada goose | 0.00 (0.00)b | 0.06 (0.43)ab | 0.04 (0.12)ab | 0.28 (0.94)a |
|  | Mallard | 0.00 (0.00)a | 0.00 (0.00)a | 0.00 (0.03)a | 0.05 (0.32)a |
| 5 | Canada goose | 0.00 (0.00)a | 0.00 (0.00)a | 0.03 (0.09)a | 0.03 (0.11)a |
|  | Mallard | 0.10 (0.68)a | 0.00 (0.00)a | 0.06 (0.28)a | 0.18 (0.69)a |

mallards ($F$ = 0.49, df = 1,378, $P$ = 0.484), wood ducks ($F$ = 0.19, df = 1,378, $P$ = 0.666), and total pairs ($F$ = 0.11, df = 1,378, $P$ = 0.737) did not differ between wetlands in public vs. private ownership.

Pair distribution among wetlands.-- Seasonal (37.5%) and semipermanent marshes (33.6%) contributed the greatest proportions of total IBP estimates (all species combined) (Figure 12). Ponds contributed an average of 23.2% of the IBP estimate, while temporary marshes and stream segments accounted for < 6.0% of total pair population estimates. Semipermanent marshes accounted for the largest proportion of blue-winged teal (54.5%) and Canada goose (53.1%) pair populations, and seasonal marshes accounted for the largest proportion of mallard (37.2%) and wood duck (44.5%) pairs (Figure 13). Semipermanent marshes (27.6%) and ponds (28.7%) also contributed to mallard pair populations estimates.

Brood distribution among wetlands.--Waterfowl broods (Canada geese, mallards, and wood ducks combined) observed on semipermanent marshes contributed the largest proportion (38.9%) to the total brood estimate (Figure 14). Ponds and seasonal marshes were also major contributors, accounting for 35.3% and 22.3% of the brood population estimate, respectively. Less than 4% of broods were associated with temporary marshes and stream segments. Semipermanent marshes contributed the largest proportion (45.3%) to the Canada goose brood estimate (Figure 15). Ponds contributed the largest proportion (62.1%) to the mallard brood estimate; however, semipermanent marshes were most important during later surveys in 1991.

Wetland basin selection.--Some wetland basins classified from NWI were altered by human activity. Therefore, wetlands were classified as they appeared during surveys. Ninety-three, 52, 60, and 78 temporary, seasonal, semipermanent marshes, and ponds were used in analyses of wetland selection in 1990. One hundred twenty, 64, 71, 110, and 28 temporary, seasonal, semipermanent marshes, ponds, and stream segments were used in 1991 analyses.

Semipermanent marshes were the most preferred wetland type when number of IBPs/wetland was examined. Without consideration of total wetland area,

Figure 12. Percent distribution of the total estimated breeding pair population of waterfowl (blue-winged teal, Canada geese, mallards, and wood ducks, combined) among semipermanent, seasonal, and temporary marshes and pond and streams during 23 March - 10 April 1990 (census 1), 18 April - 8 May 1990, (census 2), 1-18 April 1991, (census 3), 27 April - 17 May 1991 (census 4), and 25 May - 12 June 1991 (census 5) in northeastern Illinois.

# Distribution of Breeding Pairs

## Contribution of Basin Types

## Total Pairs

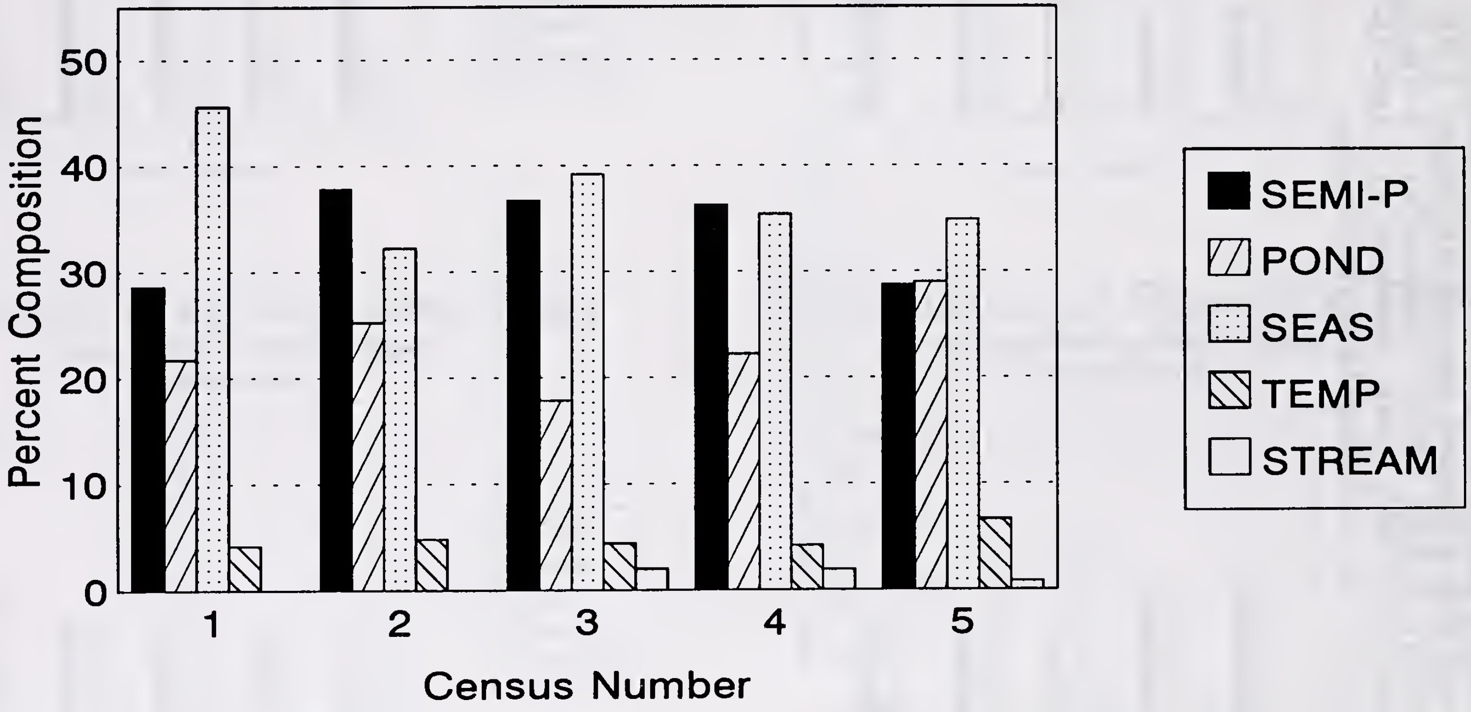
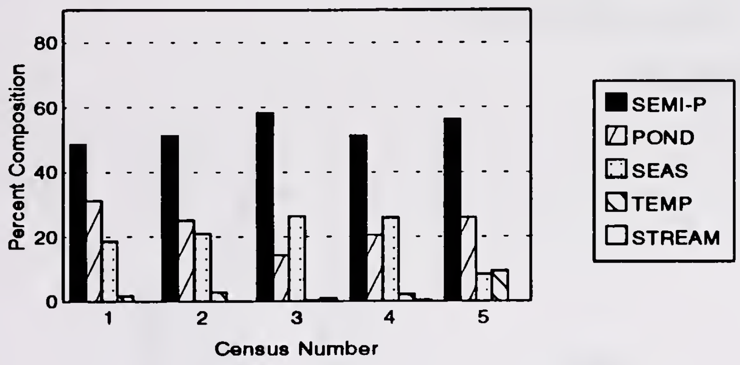
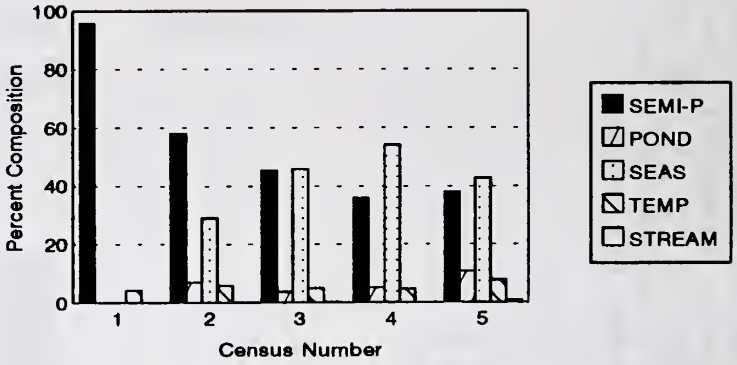


Figure 13. Percent distribution by species of estimated breeding pair populations of blue-winged teal, Canada geese, mallards, and wood ducks among semipermanent, seasonal, and temporary marshes and pond and streams during 23 March - 10 April 1990 (census 1), 18 April - 8 May 1990, (census 2), 1-18 April 1991, (census 3), 27 April - 17 May 1991 (census 4), and 25 May - 12 June 1991 (census 5) in northeastern Illinois.

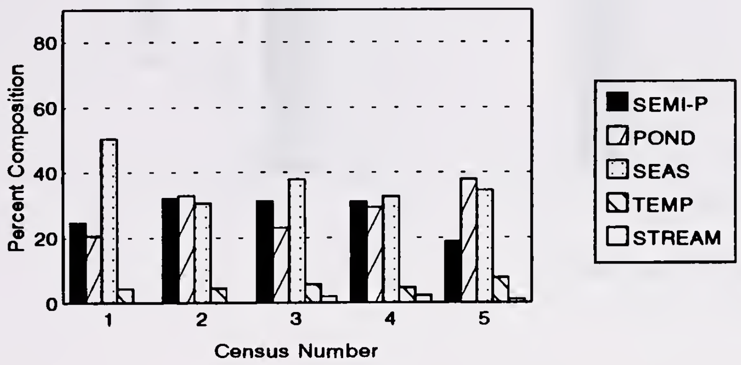
Distribution of Breeding Pairs
Contribution of Basin Types
Canada Geese



Distribution of Breeding Pairs
Contribution of Basin Types
Blue-winged Teal



Distribution of Breeding Pairs
Contribution of Basin Types
Mallards



Distribution of Breeding Pairs
Contribution of Basin Types
Wood Ducks

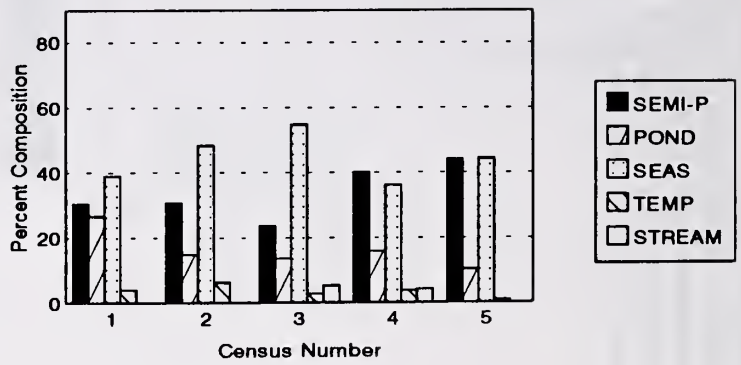


Figure 14. Percent distribution of the total estimated population of waterfowl broods (Canada geese, mallards, and wood ducks, combined) among semipermanent, seasonal, and temporary marshes and pond and streams during 18 April - 8 May 1990, (census 2), 27 April - 17 May 1991 (census 4), and 25 May - 12 June 1991 (census 5) in northeastern Illinois.

# Distribution of Brood Population

## Contribution of Basin Types

## Total Broods

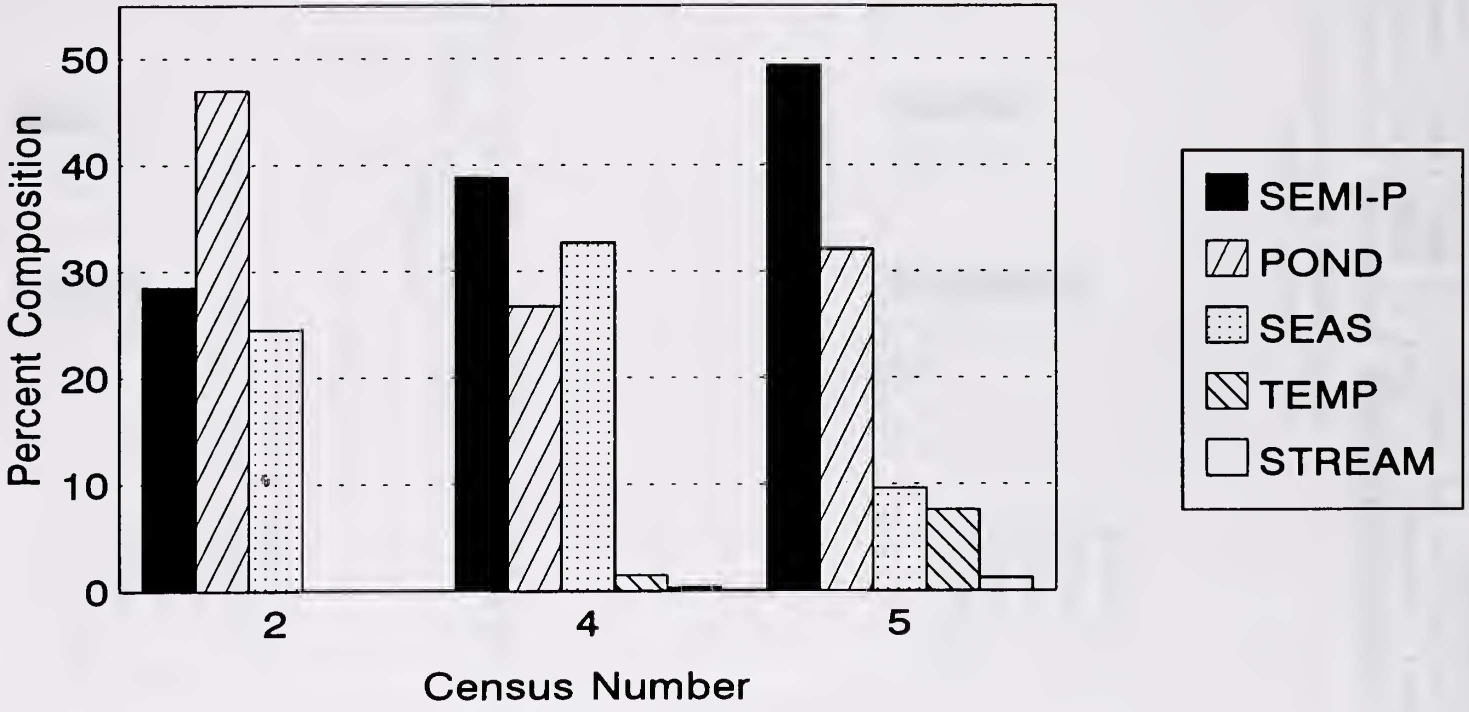
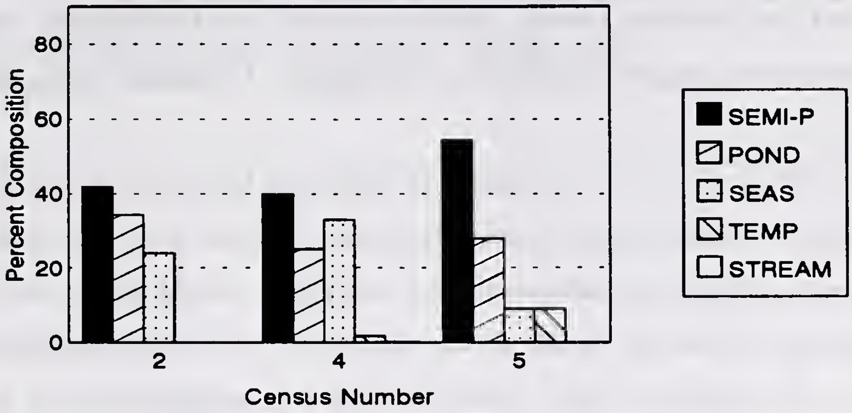


Figure 15. Percent distribution by species of estimated populations of Canada goose and mallard broods among semipermanent, seasonal, and temporary marshes and pond and streams during 18 April - 8 May 1990, (census 2), 27 April - 17 May 1991 (census 4), and 25 May - 12 June 1991 (census 5) in northeastern Illinois.

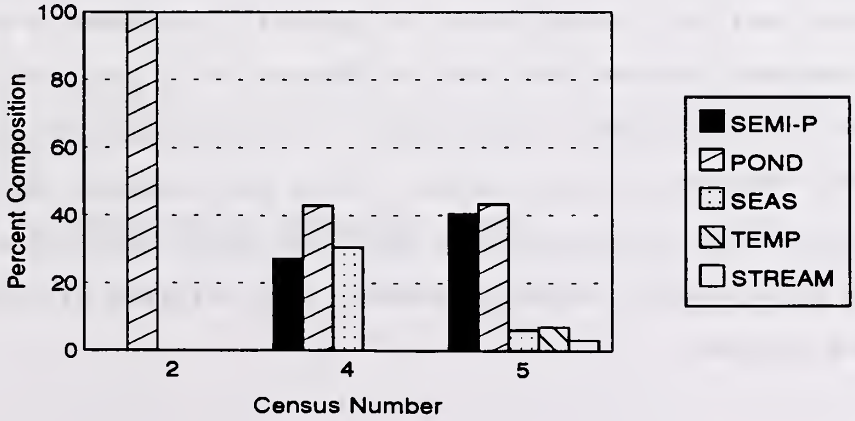
# Distribution of Brood Population

Contribution of Basin Types
Canada Geese



# Distribution of Brood Population

Contribution of Basin Types
Mallards



semipermanent marshes were preferred by all 4 species in all surveys. Temporary marshes were generally avoided. Seasonal marshes were used in proportion to availability except by Canada geese which avoided seasonal marshes. Ponds were avoided by all species except mallards which used ponds in proportion to availability. Stream segments were preferred by wood ducks, used in proportion to availability by mallards, but were avoided by blue-winged teal and Canada geese. These results reflected the large average size of semipermanent marshes compared to smaller temporary and seasonal marshes and ponds.

When wetland use in relation to wetland basin area was examined, semipermanent marshes were less preferred (Table 13). Blue-winged teal and Canada geese preferred semipermanent marshes, while mallards avoided semipermanent marshes. Wood ducks generally used semipermanent marshes in proportion to availability. Use of seasonal marshes varied among species and surveys, but were generally preferred or used in proportion to availability. Temporary marshes were almost universally avoided. Ponds were used in proportion to availability and preferred by mallards. Stream segments were avoided by all species except wood ducks that used them in proportion to availability.

When wetland use in relation to inundated wetland area was examined, temporary marshes were used in proportion to availability by all species and preferred by mallards (Table 14). Semipermanent marshes were preferred by blue-winged teal and Canada geese, but generally avoided by mallards and wood ducks. Seasonal marshes were used in proportion to availability by blue-winged teal, Canada geese, and mallards. A slight preference for seasonal marshes was detected for wood ducks. Ponds were avoided by blue-winged teal, used in proportion to availability by Canada geese and wood ducks, and preferred by mallards. Stream segments, when analyzed by inundated wetland area, were avoided.

Table 13. Wetland selection (based on proportions of indicated breeding pairs (IBPs) observed in relation to total area of wetland types) by breeding waterfowl observed 23 March - 10 April 1990 (Census 1), 18 April - 8 May 1990 (Census 2), 1-18 April 1991 (Census 3), 27 April - 17 May 1991 (Census 4), and 25 May - 12 June 1991 (Census 5) in northeastern Illinois.

| | | Wetland type | | | | |
|---|---|---|---|---|---|---|
| Species | Census number | Semi-permanent marsh | Seasonal marsh | Temporary marsh | Pond | Stream |
| Blue-winged teal | 1 | + | - | - | - | |
| | 2 | + | 0 | - | - | |
| | 3 | + | + | - | - | - |
| | 4 | + | + | - | 0 | - |
| | 5 | 0 | 0 | 0 | 0 | - |
| Canada goose | 1 | 0 | 0 | - | 0 | |
| | 2 | + | 0 | - | 0 | |
| | 3 | + | 0 | - | 0 | - |
| | 4 | + | 0 | - | + | - |
| | 5 | + | - | 0 | + | - |
| Mallard | 1 | - | + | - | + | |
| | 2 | - | 0 | - | + | |
| | 3 | 0 | + | - | + | - |
| | 4 | - | 0 | - | + | - |
| | 5 | - | + | 0 | + | - |
| Wood duck | 1 | 0 | 0 | - | + | |
| | 2 | 0 | + | 0 | 0 | |
| | 3 | - | + | - | 0 | 0 |
| | 4 | 0 | 0 | - | 0 | 0 |
| | 5 | + | + | - | - | - |

'+' = selection
'-' = avoidance
'0' = use in proportion to availability

Table 14. Wetland selection (based on proportions of indicated breeding pairs (IBPs) observed in relation to total inundated area of wetland types) by breeding waterfowl observed 23 March - 10 April 1990 (Census 1), 18 April - 8 May 1990 (Census 2), 1-18 April 1991 (Census 3), 27 April - 17 May 1991 (Census 4), and 25 May - 12 June 1991 (Census 5) in northeastern Illinois.

| | | Wetland type | | | | |
|---|---|---|---|---|---|---|
| Species | Census number | Semi-permanent marsh | Seasonal marsh | Temporary marsh | Pond | Stream |
| Blue-winged teal | 1 | + | - | 0 | - | |
| | 2 | + | 0 | 0 | - | |
| | 3 | + | + | 0 | - | - |
| | 4 | + | + | 0 | - | - |
| | 5 | + | 0 | 0 | 0 | - |
| Canada goose | 1 | 0 | 0 | 0 | 0 | |
| | 2 | 0 | 0 | 0 | 0 | |
| | 3 | + | 0 | - | 0 | - |
| | 4 | + | 0 | - | 0 | - |
| | 5 | + | - | 0 | + | - |
| Mallard | 1 | - | + | + | 0 | |
| | 2 | - | 0 | 0 | + | |
| | 3 | 0 | 0 | + | + | - |
| | 4 | 0 | 0 | + | + | - |
| | 5 | - | 0 | + | + | - |
| Wood duck | 1 | - | 0 | 0 | 0 | |
| | 2 | - | + | + | 0 | |
| | 3 | - | + | 0 | 0 | 0 |
| | 4 | + | 0 | 0 | 0 | - |
| | 5 | + | + | - | - | - |

'+' = selection
'-' = avoidance
'0' = use in proportion to availability

## Habitat Relationships

NWI habitat variables.--Regression analyses were used to relate mean IBPs/wetland/visit of Canada geese, mallards, wood ducks, blue-winged teal, and total pairs (4 species combined) to total wetland area and areas of each NWI habitat type within surveyed wetlands (Table 15). Two to 5 significant relationships were identified with $\underline{R}^2$ values ranging from 0.411 to 0.614 depending on species. Canada geese pair densities were positively associatedwith area of pond habitat and total wetland area, but were negatively associated with area of seasonal and semipermanent emergent wetland habitat. Mallards pair densities were positively associated with total wetland area, area of pond habitat, and seasonal emergent habitat. Wood duck pair densities were positively associated with area of semipermanent emergent, pond, wooded emergent habitat, and total wetland area but were negatively associated with area of temporary emergent wetland habitat. Blue-winged teal pair densities were positively associated with total wetland area and negatively associated with area of temporary emergent wetland habitat. Total wetland area explained most of the variability in pair densities on individual wetlands for mallard, blue-winged teal, and total pairs.Total pairs (all species) observed/wetland/ visit were positively associated with total wetland area and area of pond habitat ($\underline{R}^2 = 0.614$).

Multiple regression analyses of mean number of broods/wetland/visit for Canada geese, mallards, wood ducks, and total broods (3 species combined) regressed on total wetland area and area of each habitat type within the wetland identified no more than 2 significant variables with $\underline{R}^2$ values ranging from 0.058 to 0.281 (Table 16). Total wetland area was positively associated with densities of Canada goose, mallard, wood duck, and total broods but was not a significant variable after other variables entered the model. Canada goose, mallard, and total brood densities were positively associated with area of pond habitat within wetlands. Canada goose brood densities were positively associated with total wetland area. Mallard brood densities were negatively

Table 15. Multiple regression analysis for mean indicated breeding pairs/wetland/visit of Canada geese, mallards, wood ducks, blue-winged teal, and total pairs (4 species combined) regressed on wetland habitat variables in northeastern Illinois during 1990-91.

| Species | Variable | P | Partial $R^2$ | Model $R^2$ | Sign of Parameter |
|---|---|---|---|---|---|
| Canada geese | POND | 0.0001 | 0.4255 | 0.4255 | + |
| | TOTAL | 0.0001 | 0.0409 | 0.4664 | + |
| | SEAS | 0.0003 | 0.0211 | 0.4875 | - |
| | SEMI-P | 0.0080 | 0.0111 | 0.4986 | - |
| Mallards | TOTAL | 0.0001 | 0.4454 | 0.4454 | + |
| | POND | 0.0001 | 0.0324 | 0.4778 | + |
| | SEAS | 0.0460 | 0.0064 | 0.4843 | + |
| Wood ducks | SEMI-P | 0.0001 | 0.2887 | 0.2887 | + |
| | POND | 0.0001 | 0.0603 | 0.3490 | + |
| | WOOD | 0.0001 | 0.0479 | 0.3969 | + |
| | TEMP | 0.0001 | 0.0270 | 0.4238 | - |
| | TOTAL | 0.0324 | 0.0082 | 0.4320 | + |
| Blue-winged teal | TOTAL | 0.0001 | 0.3911 | 0.3911 | + |
| | TEMP | 0.0010 | 0.0202 | 0.4112 | - |
| Total pairs | TOTAL | 0.0001 | 0.5564 | 0.5564 | + |
| | POND | 0.0001 | 0.0570 | 0.6135 | + |

Table 16. Multiple regression analysis for mean number of broods/wetland/visit of Canada geese, mallards, wood ducks, and total broods (3 species combined) regressed on wetland habitat variables in northeastern Illinois during 1990-91.

| Species | Variable | P | Partial $R^2$ | Model $R^2$ | Sign of Parameter |
|---|---|---|---|---|---|
| Canada geese | POND | 0.0001 | 0.2521 | 0.2521 | + |
| | TOTAL | 0.0004 | 0.0288 | 0.2809 | + |
| Mallards | POND | 0.0001 | 0.0840 | 0.0840 | + |
| | SEMI-P | 0.0022 | 0.0265 | 0.1105 | - |
| Wood ducks | SEMI-P | 0.0001 | 0.0576 | 0.0576 | + |
| Total broods | POND | 0.0001 | 0.2633 | 0.2633 | + |
| | WOOD | 0.0173 | 0.0129 | 0.2762 | + |

associated with semipermanent emergent habitat. Wood duck brood densities were positively associated with semipermanent emergent wetland habitat. Total brood densities were positively associated with area of pond and wooded emergent habitats. Area of pond habitat explained more variation in brood densities than other variables for Canada geese, mallards, and total broods. NWI wetland habitat variables explained little variation in densities of wood duck broods.

Seasonal habitat variables.--Multiple regression related the number of IBPs/wetland for Canada geese, mallards, wood ducks, blue-winged teal, and total pairs (4 species combined) to seasonal wetland characteristics that changed between visits. Three significant relationships were identified in each model with $\underline{R}^2$ values ranging from 0.024 to 0.055 (Table 17). Canada goose pair densities were negatively associated with percent of basin in moist soil-shallow emergent vegetation and positively associated with percent of basin with robust emergent vegetation and percent of basin inundated with water. Mallards pair densities were positively associated with area of basin inundated and percent robust emergent vegetation, but were negatively associated with submergent-floating leaf vegetation. Wood duck pair densities were positively associated with percent of basin in submergent-floating leaf vegetation and percent inundated with water, but were negatively associated with percent open water. Blue-winged teal pair densities were positively associated with percent robust emergent vegetation and percent inundated with water, but were negatively associated with percent open water. Total pair densities were positively associated with percent inundated with water, percent robust emergent vegetation, and percent shallow emergent vegetation. Seasonal wetland habitat variables were of little value in explaining wetland densities of breeding waterfowl. Although some relationships were significant, they explained very little variation in pair densities on wetlands.

Multiple regression analyses of the number of broods/wetland regressed on habitat characteristics of wetlands recorded during each visit identified

Table 17. Multiple regression analysis for indicated breeding pairs observed each wetland visit for Canada geese, mallards, wood ducks, blue-winged teal, and total pairs (4 species combined) regressed on the observed wetland habitat characteristics measured during each visit in northeastern Illinois 1990-91.

| Species | Variable | *P* | Partial $R^2$ | Model $R^2$ | Sign of Parameter |
|---|---|---|---|---|---|
| Canada geese | PERCENTA | 0.0001 | 0.0159 | 0.0159 | - |
| | PERCENTB | 0.0132 | 0.0041 | 0.0201 | + |
| | WET | 0.0110 | 0.0043 | 0.0244 | + |
| Mallards | WET | 0.0001 | 0.0150 | 0.0150 | + |
| | PERCENTB | 0.0001 | 0.0110 | 0.0260 | + |
| | PERCENTC | 0.0180 | 0.0037 | 0.0297 | - |
| Wood ducks | PERCENTC | 0.0001 | 0.0301 | 0.0301 | + |
| | WET | 0.0001 | 0.0095 | 0.0396 | + |
| | PERCENTD | 0.0001 | 0.0150 | 0.0546 | - |
| Blue-winged teal | PERCENTB | 0.0001 | 0.0121 | 0.0121 | + |
| | WET | 0.0001 | 0.0107 | 0.0229 | + |
| | PERCENTD | 0.0001 | 0.0178 | 0.0406 | - |
| Total Pairs | WET | 0.0001 | 0.0269 | 0.0269 | + |
| | PERCENTB | 0.0001 | 0.0203 | 0.0472 | + |
| | PERCENTA | 0.0375 | 0.0028 | 0.0500 | + |

1-2 significant variables for each species model. $\underline{R}^2$ values for the models were low (Table 18). Canada goose brood densities were negatively associated with percent of basin containing shallow emergent vegetation. Mallard brood densities were positively associated with percent of basin in submergent-floating leaf vegetation and open water. Wood duck brood densities were positively associated with submergent-floating leaf vegetation. Total brood densities were negatively associated with shallow emergent vegetation and positively associated with submergent-floating leaf vegetation.

Surrounding land use.--Regression analyses related mean IBPs/wetland area/visit of Canada geese, mallards, wood ducks, blue-winged teal, and total pairs (4 species combined) to proportions of land use types within 1 km surrounding wetland basins. One to 2 significant relationships were identified with $\underline{R}^2$ values ranging from 0.020 to 0.051 (Table 19). Canada geese pair densities were positively associated with area of pond habitat surrounding a wetland. Mallard pair densities were positively associated with urban habitat. Wood duck pair densities were positively associated with upland forested habitat. Blue-winged teal and total pair densities were not associated with any surrounding land use or habitat types. Few surrounding land use variables were significant and explained little of the variation in pair densities.

Regression analyses of mean number of broods/wetland area/visit for Canada geese, mallards, wood ducks, and total broods regressed on percentages of land use types within 1 km surrounding wetland basins only identified only 1 significant variable in each model (Table 20). $\underline{R}^2$ values for the models ranged from 0.019 to 0.047. Canada goose brood densities were positively associated with percent of pond habitat surrounding basins. Mallard brood

Table 18. Multiple regression analysis for the number of broods observed each wetland visit for Canada geese, mallards, wood ducks, and total broods (3 species combined) regressed on the observed wetland habitat characteristics measured during each visit in northeastern Illinois 1990-91.

| Species | Variable | P | Partial $R^2$ | Model $R^2$ | Sign of Parameter |
|---|---|---|---|---|---|
| Canada geese | PERCENTA | 0.0312 | 0.0032 | 0.0032 | - |
| Mallards | PERCENTC | 0.0087 | 0.0047 | 0.0047 | + |
| | PERCENTD | 0.0497 | 0.0026 | 0.0073 | + |
| Wood ducks | PERCENTC | 0.0001 | 0.0209 | 0.0209 | + |
| Total broods | PERCENTA | 0.0096 | 0.0046 | 0.0046 | - |
| | PERCENTC | 0.0354 | 0.0030 | 0.0076 | + |

Table 19. Multiple regression analysis for mean indicated breeding pairs/wetland area/visit of Canada geese, mallards, and wood ducks regressed on the percentages of land use types within 1 km surrounding wetland basins in northeastern Illinois during 1990-91.

| Species | Variable | *P* | Partial $R^2$ | Model $R^2$ | Sign of Parameter |
|---|---|---|---|---|---|
| Canada geese | POND | 0.0101 | 0.0203 | 0.0203 | + |
| Mallard | URBAN | 0.0007 | 0.0349 | 0.0349 | + |
| Wood duck | FOREST | 0.0001 | 0.0507 | 0.0507 | + |

Table 20. Multiple regression analysis for mean number of broods/wetland area/visit of Canada geese, mallards, wood ducks, and total broods (3 species combined) regressed on the percentages of land use types within 1 km surrounding wetland basins in northeastern Illinois 1990-91.

| Species | Variable | *P* | Partial $R^2$ | Model $R^2$ | Sign of Parameter |
|---|---|---|---|---|---|
| Canada geese | POND | 0.0123 | 0.0192 | 0.0192 | + |
| Mallard | URBAN | 0.0123 | 0.0192 | 0.0192 | + |
| Wood duck | SEMI-P | 0.0001 | 0.0465 | 0.0465 | - |
| Total broods | POND | 0.0076 | 0.0218 | 0.0218 | + |

densities were positively associated with urban habitats. Wood duck brood densities were negatively associated with semipermanent emergent wetland habitat. Total brood densities were positively associated with area of pond habitat surrounding wetland basins.

Breeding waterfowl distribution.--Mean breeding pair densities across all surveys varied from 0.23 - 2.44 (Table 21) among the 20 quadrangle map areas (Figure 2). The central quadrangles had the greatest IBP densities while the north, south, and west quadrangles generally had the lowest densities. Mallard densities ranged from 0.10 IBPs/ha in the Antioch quadrangle to 1.70 IBPs/ha in the Lake Zurich quadrangle. Wood duck IBP densities ranged from 0.01 in Lombard to 1.26 IBPs/ha in Barrington. Wood duck IBP densities were not as clustered as were mallards and had densities < 0.10 IBPs/ha in 10 of 20 quadrangles. Blue-winged teal densities ranged from 0.0 in Barrington to 0.48 IBPs/ha in Lake Zurich. Only 4 quads had blue-winged teal densities $\geq$ 0.18 IBPs/ha, including Lake Zurich (0.48 IBPs/ha), Pingree Grove (0.42 IBPs/ha), Elgin (0.22 IBPs/ha), and Woodstock (0.18 IBPs/ha). Canada goose densities ranged from 0.0 in the Barrington quad to 0.32 IBPs/ha in McHenry. Eleven of 20 quads had Canada goose IBP densities < 0.1 IBPs/ha.

Regression analyses were used to relate mean pair densities on wetlands to upland and wetland habitat composition within each quadrangle. Habitat composition within quadrangles explained 23.6 - 58.4% of variation in wetlands by IBPs.Canada goose pair densities on wetlands within quadrangle areas were positively associated with percent of the quadrangle classified as urban (Table 22). Mallard pair densities within quadrangles were positively associated with percent of pond area. Wood duck pair densities were positively associated with percent forest and negatively associated with semipermanent emergent habitats within a quadrangle. Total pairs were positively associated with percent lawn and negatively associated with wooded emergent habitats within a quadrangle.

Table 21. Mean density of indicated breeding pairs (IBPs) observed on wetlands located in United States Geological Survey (USGS) 7.5 minute quadrangle maps in northeastern Illinois springs 1990-91.

| Quadrangle Name | Composition of Habitats/Quadrangle (km²) | | | | | | IBPs/ |
|---|---|---|---|---|---|---|---|
| | Urban | Forest | Idle/ Old field | Agriculture | Palustrine Wetland | Deep Water | Wetland area/ Quad/visit |
| Hebron | 5.03 | 2.76 | 6.60 | 117.72 | 10.78 | 0.19 | 0.57 |
| Richmond | 13.26 | 6.16 | 15.74 | 91.74 | 12.63 | 3.06 | 0.84 |
| Fox Lake | 32.83 | 10.42 | 9.07 | 37.90 | 22.27 | 30.02 | 0.39 |
| Antioch | 33.30 | 8.49 | 16.21 | 56.38 | 19.87 | 8.26 | 0.23 |
| Woodstock | 17.25 | 7.24 | 23.32 | 82.11 | 12.57 | 0.02 | 0.75 |
| McHenry | 30.18 | 10.76 | 20.72 | 63.72 | 14.45 | 2.68 | 1.77 |
| Wauconda | 33.96 | 9.23 | 20.21 | 46.16 | 24.35 | 8.60 | 0.90 |
| Grayslake | 36.91 | 5.79 | 15.94 | 63.67 | 15.37 | 4.84 | 1.44 |
| Huntley | 12.35 | 2.46 | 12.47 | 99.41 | 15.58 | 0.67 | 0.37 |
| Crystal Lake | 49.49 | 6.64 | 18.82 | 56.00 | 8.33 | 3.64 | 2.03 |
| Barrington | 55.35 | 18.69 | 21.60 | 26.41 | 16.18 | 4.70 | 2.44 |
| Lake Zurich | 63.39 | 11.92 | 14.70 | 35.57 | 14.53 | 2.82 | 2.44 |
| Pingree Grove | 7.54 | 3.79 | 9.95 | 113.02 | 9.04 | 0.01 | 2.36 |
| Elgin | 59.09 | 8.40 | 13.37 | 51.12 | 8.39 | 2.97 | 1.56 |
| Streamwood | 46.34 | 10.08 | 24.94 | 49.73 | 10.14 | 2.11 | 1.75 |
| Palatine | 104.87 | 5.25 | 9.53 | 12.90 | 10.25 | 0.57 | 1.96 |
| Elburn | 19.36 | 5.38 | 8.21 | 105.08 | 5.18 | 0.55 | 0.55 |
| Geneva | 48.67 | 10.13 | 13.24 | 62.67 | 6.21 | 2.84 | 0.53 |
| West Chicago | 59.38 | 6.32 | 13.02 | 50.79 | 13.44 | 0.82 | 0.73 |
| Lombard | 99.74 | 2.68 | 11.23 | 17.97 | 11.61 | 0.52 | 1.15 |

Table 22. Multiple regression analysis of mean numbers of indicated breeding pairs (IBPs)/wetland area/ quadrangle/visit of Canada geese, mallards, wood ducks, and total pairs regressed on percent habitat composition in each United States Geological Survey (USGS) 7.5 minute quadrangles in northeastern Illinois 1990-91.

| Species | Variable | P | Partial $R^2$ | Model $R^2$ | Sign of Parameter |
|---|---|---|---|---|---|
| Canada geese | URBAN | 0.0301 | 0.2355 | 0.2355 | + |
| Mallard | POND | 0.0098 | 0.3164 | 0.3164 | + |
| Wood duck | FOREST | 0.0026 | 0.4034 | 0.4034 | + |
| | SEMI-P | 0.0148 | 0.1802 | 0.5836 | - |
| Total pairs | LAWN | 0.0314 | 0.2323 | 0.2323 | + |
| | WOOD | 0.0392 | 0.1743 | 0.4066 | - |

### Invertebrate Communities

Sixty-six taxa were identified in wetland nektonic and benthic invertebrate samples (Appendices C-H). Mean number of taxa/l in benthic core samples increased ($F$ = 5.34, df = 1,106, $P$ = 0.023) between sampling periods 1 and 2 (Table 23). Mean number of taxa/l in nektonic net sweep samples also increased ($F$ = 6.34, df = 3,257, $P$ < 0.001) between sampling periods each year. Invertebrate samples collected 25-26 May 1991 were more diverse than samples collected 15-18 April 1990. Thus, the diversity of benthic invertebrates increased as spring progressed, but nektonic samples did not show the magnitude of increase in diversity that benthic samples did.

Mean number of organisms/l in benthic and nektonic samples varied among sample periods (Table 23). No temporal differences in invertebrate density were detected in benthic ($F$ = 1.02, df = 1,106, $P$ = 0.314) and nektonic ($F$ = 1.98, df = 3,257, $P$ = 0.118) samples. Number of organisms increased in benthic samples over time, but the trend was not detected in nektonic samples. Because no differences in organisms/l were detected between sample periods, invertebrate samples were pooled across periods for further comparisons.

Benthic samples (mean = 5.9 taxa/l, SD = 2.9) were more diverse ($F$ = 972.78, df = 1,367, $P$ < 0.001) than nektonic samples (mean = 0.2 taxa/l, SD = 0.2). Benthic samples (mean = 23.4 organisms/l, SD = 26.0) also had greater densities ($F$ = 4.60, df = 1,367, $P$ = 0.033) than nektonic samples (mean = 15.9 organisms/l, SD = 32.4).

The number of taxa/l in benthic samples was greater ($F$ = 5.84, df = 3,104, $P$ = 0.001) in ponds and semipermanent marshes than in seasonal and temporary marshes (Table 24). The number of invertebrate taxa/l in nektonic samples did not differ between basin types ($F$ = 1.63, df = 3,257, $P$ = 0.182). Densities (organisms/l) of aquatic invertebrates in benthic samples did not differ between wetland types ($F$ = 1.52, df = 3,104, $P$ = 0.214), but densities in nektonic samples did differ ($F$ = 3.40, df = 3,257, $P$ = 0.018). Nektonic samples from seasonal marshes had greater densities than those collected in

Table 23. Mean (standard deviation) aquatic invertebrate taxa/l and organisms/l of benthic and nektonic samples collected 15-18 April 1990 (sampling period I), 8-10 May 1990 (sampling period II), 26-27 April 1991 (sampling period III), and 25-26 May 1991 (sampling period IV) in northeastern Illinois. Row means not sharing the same letter were statistically different ($\underline{P} \leq 0.05$; Tukey/Kramer tests).

| Parameter | Sample Type | Sampling Period I | II | III | IV |
|---|---|---|---|---|---|
| Taxa/liter | Benthic core | 5.26 (2.75)a<br>(n=56) | 6.54 (2.99)b<br>(n=52) | | |
| | Nektonic sweep | 0.14 (0.10)a<br>(n=56) | 0.20 (0.12)ab<br>(n=56) | 0.21 (0.14)ab<br>(n=76) | 0.28 (0.27)b<br>(n=73) |
| Organisms/ liter | Benthic core | 20.96 (25.11)a<br>(n=56) | 26.02 (26.96)a<br>(n=52) | | |
| | Nektonic sweep | 8.39 (32.12)a<br>(n=56) | 17.97 (25.04)a<br>(n=56) | 21.64 (41.54)a<br>(n=76) | 13.96 (25.49)a<br>(n=73) |

Table 24. Mean (standard deviation) aquatic invertebrate taxa/l and organisms/l of benthic and nektonic samples collected in ponds, semipermanent, seasonal, and temporary marshes in northeastern Illinois 1990-91. Row means not sharing the same letter were statistically different ($\underline{P} \leq 0.05$; Tukey/Kramer tests).

| Parameter | Sample Type | Basin Type | | | |
|---|---|---|---|---|---|
| | | Pond | Semipermanent Marsh | Seasonal Marsh | Temporary Marsh |
| Taxa/liter | Benthic core | 6.47 (2.97)a<br>(n=46) | 6.43 (2.66)a<br>(n=37) | 4.15 (2.21)b<br>(n=16) | 3.42 (2.35)b<br>(n=9) |
| | Nektonic sweep | 0.19 (0.20)a<br>(n=103) | 0.19 (0.14)a<br>(n=86) | 0.25 (0.21)a<br>(n=44) | 0.26 (0.28)a<br>(n=28) |
| Organisms/ liter | Benthic core | 28.19 (25.74)a<br>(n=46) | 22.92 (29.97)a<br>(n=37) | 18.01 (20.53)a<br>(n=16) | 10.43 (10.83)a<br>(n=9) |
| | Nektonic sweep | 14.71 (28.06)ab<br>(n=103) | 15.18 (26.35)ab<br>(n=86) | 27.65 (53.55)a<br>(n=44) | 3.66 (4.40)b<br>(n=28) |

temporary marshes. Nektonic invertebrate samples in temporary marshes had the lowest density of the 4 wetland types, but temporary marshes had the greatest diversity (taxa/l) among wetland types.

Samples taken in vegetation and open water were compared to determine the relationship between emergent vegetation and aquatic invertebrates communities. Diversity and density of invertebrates in benthic core samples were greater in vegetated than in open water samples (Table 25). However, pairwise comparisons detected no differences in mean taxa/l ($F$ = 0.25, df = 1,106, $P$ = 0.616) and mean organisms/l ($F$ = 0.43, df = 1,106, $P$ = 0.514). Mean number of taxa/l ($F$ = 58.25, df = 1,259, $P < 0.001$) and mean number of organisms/l ($F$ = 17.14, df = 1,259, $P < 0.001$) were greater in vegetated than in open water samples.

Aquatic invertebrates were compared among vegetation zones (moist soil-shallow emergent, robust emergent, submergent-floating leaf vegetation, and open water) within wetlands to examine relationships between aquatic invertebrates and vegetation structure. Differences in benthic samples among vegetation zones were not significant for taxa/l ($F$ = 0.69, df = 1,104, $P$ = 0.560) or organisms/l ($F$ = 0.92, df = 1,104, $P$ = 0.435). Diversity of aquatic invertebrate taxa in nektonic samples varied among the vegetation zones ($F$ = 26.84, df = 3,257, $P < 0.001$). Moist soil-shallow emergent vegetation had greater nektonic diversity than robust emergent, submergent-floating leaf vegetation, and open water samples (Table 26). Robust emergent vegetation had greater nektonic diversity than submergent-floating leaf vegetation and open water. Nektonic density differed between moist soil-shallow emergent and open water samples ($F$ = 8.04, df = 3,257, $P < 0.001$).

## DISCUSSION

### Influence of Duck Bachelor Groups

Pair bond duration (McKinney 1965, Gilmer et al. 1977) and drake sociability of North American dabbling ducks (Dzubin 1969*a*, Gilmer et al. 1977) influence enumeration of IBPs observed during breeding waterfowl

Table 25. Mean (standard deviation) aquatic invertebrate taxa/l and organisms/l of benthic core and nektonic net sweep samples collected in vegetated and open water habitats in northeastern Illinois 1990-91. Row means not sharing the same letter were statistically different ($P \leq 0.05$; Tukey/Kramer tests).

| Parameter | Sample Type | Habitat Type<br>Vegetation | <br>Open water |
|---|---|---|---|
| Taxa/liter | Benthic core | 5.96 (2.70)a<br>(n=69) | 5.69 (3.26)a<br>(n=39) |
| | Nektonic core | 0.28 (0.22)a<br>(n=156) | 0.11 (0.07)b<br>(n=105) |
| Organisms/ liter | Benthic core | 24.63 (27.73)a<br>(n=69) | 21.21 (22.88)a<br>(n=39) |
| | Nektonic core | 22.48 (39.15)a<br>(n=156) | 6.03 (13.54)b<br>(n=105) |

Table 26. Mean (standard deviation) aquatic invertebrate taxa/l and organisms/l of benthic and nektonic samples collected in moist soil-shallow emergent, robust emergent, submergent-floating leaf vegetation, and open water wetland zones in northeastern Illinois wetlands 1990-91. Row means not sharing the same letter were statistically different ($P \leq 0.05$; Tukey/Kramer tests).

| | | Wetland Zone | | | |
|---|---|---|---|---|---|
| Parameter | Sample Type | Moist soil-shallow emergent | Robust emergent | Submergent-floating leaf | Open water |
| Taxa/liter | Benthic core | 5.81 (2.43)a<br>(n=39) | 5.67 (2.90)a<br>(n=20) | 7.12 (3.26)a<br>(n=10) | 5.69 (3.26)a<br>(n=39) |
| | Nektonic sweep | 0.33 (0.24)a<br>(n=87) | 0.25 (0.19)b<br>(n=49) | 0.16 (0.06)bc<br>(n=20) | 0.11 (0.07)c<br>(n=105) |
| Organisms/liter | Benthic core | 21.87 (21.94)a<br>(n=39) | 24.36 (28.46)a<br>(n=20) | 35.94 (43.49)a<br>(n=10) | 21.21 (22.88)a<br>(n=39) |
| | Nektonic sweep | 27.82 (44.71)a<br>(n=87) | 18.03 (34.97)ab<br>(n=49) | 10.14 (4.86)ab<br>(n=20) | 6.03 (13.54)b<br>(n=105) |

surveys. Male dabbling ducks are intolerant of conspecific males until pair bonds are severed during incubation (Titman 1983). Consequently, lone males are used to indicate breeding pairs (Dzubin 1969a). Intolerant drakes become social and form bachelor groups following termination of pair bonds (Dzubin 1969a). Therefore, breeding pairs may be represented by segregated pairs, small bachelor groups (Hammond 1969, U. S. Fish and Wildl. Serv. and Can. Wildl. Serv. 1987), and lone females in excess of lone males on a wetland (Stewart and Kantrud 1972).

Male biased sex ratios of dabbling ducks (Bellrose et al. 1961) create a surplus of unmated males on breeding areas. These unmated males may elevate pair totals observed during waterfowl surveys (Diem and Lu 1960). Jackson et al. (1985) cautioned against the use of single drakes and bachelor groups in estimating breeding pair populations during drought years due to immigration of drought displaced birds. However, Dzubin (1969a) considered an important portion of a breeding duck population would be ignored if small bachelor groups were not used to indicate breeding pairs.

IBP numbers were totaled by species and survey with and without using bachelor groups ≤ 4 as indicated breeding pairs (Table 27). Bachelor groups accounted for 37% of blue-winged teal pair numbers observed during the first census; however, this survey was conducted before arrival of resident pairs. Three to 10% of blue-winged teal IBPs were accounted for by bachelor groups during the second, third, and fourth censuses, although migrant birds were still present in the area (Appendices P-R). Bachelor groups accounted for 46% of blue-winged teal IBPs during the fifth census. This was expected since drake sociability increases after dissolution of pair bonds.

A similar pattern was observed with mallard pairs (Table 27). Mallard bachelor groups contributed only 7% to pair numbers during the first census, but the proportion increased to 55% as males deserted females during the second census. The same pattern was observed during 1991 censuses; however, bachelor groups accounted for 19% of IBP numbers during the third census.

Table 27. Summary of waterfowl indicated breeding pairs (IBPs) in northeastern Illinois observed 23 March - 10 April 1990 (Census 1), 18 April - 8 May 1990 (Census 2), 1-18 April 1991 (Census 3), 27 April - 17 May 1991 (Census 4), and 25 May - 12 June 1991 (Census 5). IBPs were totaled using segregated pairs, lone males, and lone females/wetland and segregated pairs, bachelor groups ≤ 4, and lone females/wetland.

| Species | Census Number | IBPs (Pairs, Lone males, Lone females) | IBPs (Pairs, Male groups ≤ 4, Lone females) | Percent Increase |
|---|---|---|---|---|
| Blue-winged teal | | 19 | 26 | 37 |
| Mallard | 1 | 415 | 443 | 7 |
| Wood duck | | 92 | 94 | 2 |
| Blue-winged teal | | 124 | 130 | 5 |
| Mallard | 2 | 241 | 374 | 55 |
| Wood duck | | 80 | 103 | 29 |
| Blue-winged teal | | 123 | 127 | 3 |
| Mallard | 3 | 421 | 502 | 19 |
| Wood duck | | 110 | 110 | 0 |
| Blue-winged teal | | 97 | 107 | 10 |
| Mallard | 4 | 238 | 395 | 66 |
| Wood duck | | 79 | 110 | 39 |
| Blue-winged teal | | 39 | 57 | 46 |
| Mallard | 5 | 206 | 338 | 64 |
| Wood duck | | 77 | 116 | 51 |

This increase may have been due to the presence of unmated males in the population. However, the breeding season for mallards may have been earlier during the third survey causing pair bond termination and increased drake sociability.

Wood duck bachelor groups contributed 0% and 2% during the first census of 1991 and 1990, respectively (Table 27). As expected, the contribution of wood duck bachelor groups to pair totals increased with progression of the breeding season. Bellrose (1980) reported that wood ducks had more balanced sex ratios (56% male) than most other species of ducks.

Because the pair bond is severed during incubation in mallards (Bellrose 1980), males generally do not accompany hens with broods. However, Figley and Van Druff (1982) suggested that drakes accompany broods more frequently in urban areas. Figley and Van Druff (1982) reported 7% of mallard broods were accompanied by drakes in an urban area of Florida. Thirteen of 72 (18.1%), of mallard broods observed in northeastern Illinois were accompanied by males, and 4 of 7 (57.1%) of mallard hybrid broods observed were accompanied by drakes. Brood rearing and molting areas in urban environments may not be distinctly separate making pair reunification easier (Figley and Van Druff 1982).

## Importance of Northeastern Illinois as Breeding Waterfowl Habitat

Pair populations.--Breeding waterfowl densities (5.50 pairs/km2) on palustrine wetlands in northeastern Illinois were lower than in the primary breeding grounds of the prairie pothole region (Evans and Black 1956). However, northeastern Illinois pair densities were similar to areas of secondary importance in the prairie pothole region (Evans and Black 1956) and were comparable to densities recorded during drought years in the primary production areas of the northern great plains. The Redvers study area in the aspen parklands of Canada had a 14 year average of 26.33 pairs/km$^2$, ranging from a low in drought years of 4.02 pairs/km$^2$ to a high of 46.41 pairs/km$^2$ in a year of ample precipitation (Stoudt 1969, 1971). Densities of 17.53 and 24.98

pairs/km$^2$ were reported for the Waubay study area in South Dakota (Evans and Black 1956, Drewien and Springer 1969). Brewster et al. (1976) reported 13.90 and 18.15 pairs/km$^2$ for the Coteau des Prairie, and 4.63 pairs/km$^2$ for the James River Lowlands of South Dakota that Evans and Black (1956) characterized as secondary area for duck production. Stewart and Kantrud (1974) reported a 3-year average of 17.18 pairs/km$^2$ for the prairie pothole region of North Dakota.

Estimated density of breeding waterfowl in northeastern Illinois was greater than the 3.37 pairs/km$^2$ reported in east-central Wisconsin (Wheeler and March 1979). Northeastern Illinois pair densities were greater than a 6 year mean of 2.33 pairs/km$^2$ in southern Ontario (Dennis 1989) and 0.75 - 1.08 pairs/km$^2$ in northern Ontario (Ross 1987).

Estimated mean density of blue-winged teal in northeastern Illinois was 0.40 IBPs/km$^2$, far lower than 5.37 - 12.30 pairs/km$^2$ observed in North Dakota and South Dakota (Drewien and Springer 1969, Stewart and Kantrud 1974). Blue-winged teal densities in northeastern Illinois were also lower than 2.15 pairs/km$^2$ reported east-central Wisconsin (Wheeler and March 1979). Estimated density of mallards in northeastern Illinois was 3.38 pairs/km$^2$, comparing favorably to 1.89 - 4.25 pairs/km$^2$ observed in the Coteau des Prairies of South Dakota, the prairie pothole region of North Dakota, and southern Ontario (Stewart and Kantrud 1974, Brewster et al. 1976, Godin and Joyner 1981). Northeastern Illinois mallard pair densities were greater than 0.62 - 0.77 pairs/km$^2$ observed in southern Ontario and in east-central Wisconsin (Dennis 1989, Wheeler and March 1979). Combined mallard and blue-winged teal density of 3.78 pairs/km$^2$ in northeastern Illinois was also comparable to 2.93 pairs/km$^2$ reported in Wisconsin by Gates (1965). Wood duck densities in northeastern Illinois averaged 0.86 IBPs/km$^2$ and were greater than 0.01 - 0.05 pairs/km$^2$ reported for northern Ontario, South Dakota, and east-central Wisconsin (Brewster et al. 1976, Wheeler and March 1979, Ross 1987). Bacon (1990) recorded a wood duck density of 0.12 pairs/km$^2$ in northern Wisconsin that was lower than in northeastern Illinois. Mean densities of Canada geese in northeastern Illinois were 0.86 pairs/km$^2$, greater than 0.01 - 0.04 pairs/km$^2$ observed in northern Ontario (Ross 1987).

Low (Ill. Nat. Hist. Surv., unpubl. data) reported small numbers of American black ducks breeding in northeastern Illinois in 1941-42. However, no evidence of American black duck breeding was observed during this study.

The elusive behavior and preference for wooded habitats (Bellrose 1980) by wood ducks has limited implementation of census methods for this species (Fredrickson and Graber 1990). Selected wetland surveys generally have not produced useful estimates of breeding wood duck densities (Brakhage 1990, Robb 1990). Wood duck population management is hindered by poor understanding of seasonal habitat needs and lack of adequate census methods (Fredrickson and Graber 1990, Serie and Chasko 1990). Population surveys conducted on randomly selected wetlands in northeastern Illinois produced consistent pair population estimates. However, wetland surveys produced few observations of wood duck broods, suggesting that wade/walk censuses of wetland basins may be of limited value in providing production indices for this species.

Production.--Brood densities of 0.73 broods/km$^2$ in northeastern Illinois were considerably lower than 9.11 broods/km$^2$ reported for the Waubay study area in the prairie pothole region of South Dakota (Evans and Black 1956), and the 14 year average of 8.49 broods/km$^2$ reported on the Redvers study area in the aspen parklands of Ontario, Canada (Stoudt 1971). Brood densities at Redvers ranged from 1.16 to 19.31 broods/km$^2$ in years of drought to ample precipitation (Stoudt 1971). Northeastern Illinois brood densities were more comparable to the 1.04 broods/km$^2$ observed in east-central Wisconsin (Wheeler and March 1979) and were slightly larger than the 0.55 broods/km$^2$ reported for the Tracy Mountain study area in western North Dakota (Lokemoen 1973).

Canada geese (0.44 broods/km$^2$) were the most abundant broods in northeastern Illinois, followed in decreasing order by mallards and wood ducks. Mallard brood densities (0.25 broods/km$^2$) observed in northeastern Illinois were considerably smaller than reported for the Redvers study area ranging from 0.77 - 9.27 broods/$km^2$ (Stoudt 1971) and 1.2 - 1.8 broods/$km^2$ reported in southern Ontario (Godin and Joyner 1981). Mallard brood densities in northeastern Illinois more similar to the 0.85 broods/$km^2$ reported on the Waubay study area in South Dakota (Evans and Black 1956) and equal to the 0.25 and 0.23 broods/$km^2$ observed at the Tracy Mountain study area in western North Dakota (Lokemoen 1973) and east-central Wisconsin (Wheeler and March 1979). Northeastern Illinois wood duck density of 0.04 broods/$km^2$ was comparable to the 0.01 broods/$km^2$ reported for east-central Wisconsin (Wheeler and March 1979). No blue-winged teal broods were observed during regular spring wetland surveys in northeastern Illinois; however, our surveys were terminated 8 May 1990 and 12 June 1991. Less than 10% of the blue-winged teal broods observed in Wisconsin hatched before the third week in June (Wheeler and March 1979). Likewise, Glover (1956) reported 75% of the blue-winged teal ducklings in northwest Iowa hatched between 15-30 June. Therefore, waterfowl surveys in this study were probably terminated before hatching of blue-winged teal. Blue-winged teal production did occur in northeastern Illinois based on 5 broods observed during wetland surveys in July 1990.

Large pair populations do not necessarily indicate high production of young (Dzubin 1969b). Hens may forego nesting attempts due to lack of habitat during (Dzubin 1969b, Jackson et al. 1985) or nest success may be low in some locations and/or years. Productivity indices were derived from estimated pair : brood population ratios on northeastern Illinois palustrine wetlands. Productivity indices were minimum estimates because: 1) migrant or transient pairs may have been present on the study area, 2) the number of pairs or hens losing entire broods was unknown, 3) low detectability of broods, and 4) renesting efforts by ducks were not accounted for.

There was a large disparity between numbers of mallard and wood duck breeding pairs, and broods observed. The mallard productivity index of 0.07 for northeastern Illinois was much lower than indices of 0.40 (Lokemoen 1973), 0.31 (Stoudt 1971), 0.30 (Wheeler and March 1979), 0.31 (Smith 1971), and 0.78 (Godin and Joyner 1981) reported in other areas. Dwyer (1970) observed a productivity index of 0.11-0.18 for mallards in the aspen parklands of Alberta, Canada, a level of production that was more comparable to northeastern Illinois. The wood duck productivity index of 0.05 was far lower than 0.24 reported for east-central Wisconsin (Wheeler and March 1979). This could have largely been caused by low detectability of wood duck broods in dense emergent habitats.

Mallard nest success in the prairie pothole region of the United States has been recently estimated at 5 - 19% (Klett et al. 1988). Mallards had a 7% nest success from 1966-84 in North Dakota (Klett et al. 1988). Cowardin et al. (1985) reported that 15% nest success and 31% and hen success (a function of nest success and renesting effort) rates were necessary to maintain stable mallard populations in an agricultural area of North Dakota. The mallard productivity index of 0.07 (indicating minimum nest success of 7%) may indicate that reproduction was not adequate to replace adult mortality in mallards breeding in northeastern Illinois.

The productivity index of 0.51 for Canada geese indicated that at least half of Canada goose pairs in northeastern Illinois produced broods. However, nest success was 74%. The disparity between these 2 measures of production could be explained by loss of entire broods and failure of some pairs to nest. Lawrence (1987) reported that 20 of 139 (14%) brooding Canada goose females in west-central Illinois lost entire broods.

## Habitat Use

Many environmental factors influence wetland use by breeding waterfowl. Burger (1985) suggested that plant form and structure play important roles in habitat selection by birds. Amount of aquatic vegetation was the most important factor affecting waterfowl use of flood prevention reservoirs in north central Texas (Hobaugh and Teer 1981). Marshes with an interspersion of emergent vegetation and open water attract greater diversity and numbers of breeding birds (Weller and Spatcher 1965). Kaminski and Prince (1981) suggested that dabbling ducks used cover : water interspersion as proximate cues to aquatic foods. Dwyer et al. (1979) thought that cover adjacent to wetlands was important in determining the attractiveness of wetlands to dabbling ducks. Wetland basins with uplands planted in cool season grasses are considered prime waterfowl nesting habitats (Duebbert 1968, Stoudt 1969, Duebbert and Kantrud 1974, Duebbert and Lokemoen 1976).

Wetland basin use.--Numbers of waterfowl breeding pairs on palustrine wetlands in northeastern Illinois increased, but not proportionally, with basin size. Although large seasonal and semipermanent basins held the greatest numbers of breeding pairs, the greatest densities (per wetland area) occurred on ponds in northeastern Illinois.

Murphy et al. (1984) also reported that small wetlands supported the greatest waterfowl densities. Use of stock ponds in Montana was a function of pond size rather than pond age, vegetation structure, or other habitat features (Hudson 1983). In contrast, studies of urban stormwater-control impoundments found that pond size was not a major factor influencing duck use (Adams et al. 1985). The relationship between basin size and numbers of waterfowl pairs was seldom significant in South Dakota (McEnroe 1976). Likewise, Drewien and Springer (1969) reported that pond size did not influence wetland use in the prairie pothole region.

Preference for small, numerous, and dispersed wetlands such as ponds in northeastern Illinois reflected the need for isolation by breeding pairs. Because of their relatively large average size and total area, seasonal and semipermanent basins accounted for the largest numbers of breeding pairs. LaGrange and Dinsmore (1989) concluded that large wetlands have more feeding sites due to greater interspersion of habitats, provide security from predators, and provide adequate space for pair isolation.

Wetland selection by breeding waterfowl was based on the assumption that pairs used wetland types in proportion to availability unless basins were actively preferred or avoided (Gilmer et al. 1975). Wetland use expressed as pairs/wetland indicated that semipermanent marshes were the most important basin type and were preferred by all species across all 5 wetland surveys.

Larger semipermanent marshes were less preferred when pairs/basin area was considered. Pair use data expressed with regard to presence or absence of water emphasized pair use of temporary marsh basins as predicted by Swanson and Duebbert (1989).

Blue-winged teal were most selective in their use of different wetland types. Mulhern et al. (1985) found that blue-winged teal used wetlands disproportionately but were not consistent in their choices. The same pattern was observed in use of seasonal wetlands by blue-winged teal in northeastern Illinois. Teal selected semipermanent marshes and used temporary marshes proportionally in all surveys. Teal consistently avoided streams and generally avoided ponds. Jessen et al. (1964) found that blue-winged teal pair densities were greater on more permanent basins in Minnesota, but reported high densities of pairs on ponds that teal avoided in northeastern Illinois. Blue-winged teal in the aspen parklands of Saskatchewan and the prairie potholes of South Dakota also had high pair densities on stock watering and dugout ponds (Stoudt 1971, RuWaldt et al. 1979). Drewien and Springer (1969) reported that temporary wetlands were not essential to breeding blue-winged teal on the Waubay study area, South Dakota. Stoudt (1971) also reported low use of temporary wetlands; however, Evans and Black (1956) suggested that temporary wetlands were very important during the breeding season.

Wetland use by breeding mallards in northeastern Illinois differed considerably from blue-winged teal. Mallards preferred ponds and temporary marshes, and used seasonal marshes in proportion to availability. Use of semipermanent marshes varied among surveys but were generally not preferred. Stream segments were avoided by mallards. Gilmer et al. (1975) also reported that mallard pairs preferentially used wetland habitats in Minnesota. Pairs preferred seasonal wetlands and ponds, and used temporary and semipermanent marshes in proportion to availability. Stoudt (1971) reported high mallard pair numbers per area of temporary wetlands, while ponds received the highest pair use of all wetland types. Similar results were also reported in South

Dakota (RuWaldt et al. 1979). Heidorn et al. (1991) also suggested that mallards in northeastern Illinois preferred pond-like basins with little emergent vegetation in the center. In contrast, Mulhern et al. (1985) determined that mallards in the aspen parklands of Saskatchewan were not selective and used structurally different wetlands proportionally.

Breeding wood ducks in northeastern Illinois used wetlands preferentially, but selection patterns varied among censuses. Wood ducks generally used ponds in proportion to availability. Use of marsh type basins varied the most, but less permanent wetlands appeared to receive greater use. Open marsh habitats at Mingo Swamp in southeast Missouri were not heavily utilized during fall migration (Heitmeyer and Fredrickson 1990), and seasonal and semipermanent marshes in eastern South Dakota received little use by brooding wood duck hens (Smith and Flake 1985). River oxbows in South Dakota were reported as important wood duck habitat (Smith and Flake 1985). Wood duck use of stream segments was lower than expected although streams were composed of approximately 35% wooded emergent habitat (Figure 10). Wood ducks returning to Mingo Swamp in Missouri during early spring congregated on riverine and palustrine scrub/shrub areas, and selected live forested habitat (Heitmeyer and Fredrickson 1990). Heitmeyer and Fredrickson (1990) suggested that streams and rivers may be used only when more preferred habitats were not available.

Wetland use by Canada geese in northeastern Illinois varied among censuses. Differential wetland use by geese was not observed during either census in 1990. However, semipermanent marshes were preferred and temporary marshes and stream segments avoided in 1991. Ponds and seasonal marshes were used proportionally. Avoidance of temporary marshes by geese may be due to lack of adequate nest sites and open water. Conover and Kania (1991) reported a strong correlation between the number of geese at a site and the ability of a goose to detect approaching predators.

Heidorn et al. (1991) suggested that geese prefer pond-like wetlands with open water centers in northeastern Illinois. This study did not detect such a preference. However, area of pond habitat within a wetland was positively related to Canada goose, mallard, wood duck, and total pair densities.

Approximately 50% of waterfowl broods were located on wetlands between 2 and 30 ha. Canada goose, mallard, and total brood densities were positively associated with area of pond habitat within wetlands. However, total area of pond habitat within basins explained little variation in number of mallard broods/wetland. Adams et al. (1985) found that pond size was not a major factor affecting brood use of urban stormwater control impoundments. Presence of emergent vegetation accounted for little variation in brood densities on wetlands in northeastern Illinois.

Other authors reported similar results on brood use of wetlands. Mallard broods densities in Saskatchewan were highest on dugout ponds (Stoudt 1971), and Lokemoen (1973) reported brood use was not related to emergent vegetation in ponds. In contrast, Evans and Black (1956) indicated that broods prefer large wetlands that offer escape cover.

Seasonal habitat variables measured during each visit explained little variation in waterfowl pair densities on palustrine wetlands. Percent of basin with surface water was positively related to pair densities for all species observed, but percent of basin in open water explained more of the variation in pair densities of wood ducks and blue-winged teal. Percent open water was negatively associated with numbers of breeding pairs for these species. McEnroe (1976) reported that areas of inundation and open water were major factors influencing waterfowl pair densities. Mallard pairs were positively related to surface water area without vegetation. This reflected the of high use of stock watering ponds in South Dakota (McEnroe 1976). Mallards in northeastern Illinois preferred ponds; however, percent of basin in open water did not influence mallard pair densities. The relationship between percent open water and blue-winged teal and wood duck pair densities were negative, probably due to avoidance of ponds by blue-winged teal and use of ponds in proportion to availability by wood ducks.

Percent of basin comprised of different aquatic vegetation zones (moist-soil, shallow emergent, robust emergent, and submergent-floating leaf vegetation) did not explain much variation in breeding waterfowl densities on palustrine wetlands in northeastern Illinois. Additionally, no relationships were detected between pair densities of any species and vegetation : open water interspersion. Thus, vegetation structure as measured in this study had little influence on wetland use by breeding waterfowl pairs in northeastern Illinois. Seasonal wetland habitat variables measured during each visit also appeared to have little influence on wetland use by waterfowl broods. At best, only 2% of variation in brood densities was explained by these variables. Mack and Flake (1980) reported that interspersion of emergent vegetation and open water was an important factor affecting use of wetlands by waterfowl broods on South Dakota stock ponds. Belanger and Couture (1988) reported that brood use was greater on wetlands containing emergent vegetation, and Courcelles and Bedard (1979) reported that mallard broods preferred broken cattail habitat in a large marsh in southwestern Quebec.

Multiple regression analyses relating mean pair densities on individual basins to land use and habitat availability within 1 km explained little variation in waterfowl use of censused wetlands in northeastern Illinois. Canada goose, mallard, and wood duck pair densities had positive associations with area of pond, urban, and forested habitats surrounding wetland basins. A positive relationship between mallard pairs and urban habitats was also reported in Florida (Figley and Van Druff 1982). However, no land use variable explained more than 6% of variation in wetland use for any species in northeastern Illinois.

Land use surrounding wetland basins also explained little variation in brood densities. Canada goose broods and total broods showed slight positive associations with percent of pond habitat within 1 km surrounding a basin. This was consistent with the positive relationship of brood densities with area of pond habitat within wetlands. Higher mallard brood densities were associated with urban environments, and wood duck broods were negatively associated with percent of semipermanent emergent habitat surrounding a basin.

Breeding pair densities varied considerably between quadrangle map areas in association with overall land use and habitat composition within quadrangle map areas. A positive relationship between Canada goose pair densities and urban area within quadrangles reflected the adaptability of this species to urban environments. The positive relationship between mallard pairs and percent pond habitat within a quadrangle reflected higher mallard densities on ponds and preference for pond basins. Relationships between mallard pairs and ponds also indicated the adaptability of this species to urban environments since ponds occurred with relatively high density in urban areas. A positive relationship between wood duck pairs and percent forest habitat indicated the preference by this species for forested habitats (Bellrose 1980, Brakhage 1990, Heitmeyer and Fredrickson 1990). The negative relationship between wood duck pairs and percent semipermanent emergent habitat substantiated the conclusion that wood duck pairs generally preferred less permanent marsh basins.

Habitat composition at the quadrangle scale explained more variation in wetland use by breeding waterfowl than habitat composition within 1 km surrounding wetlands. This could have occurred because breeding pairs may select habitats from larger areas than 1 km surrounding wetlands. Most blue-winged teal, mallard, and wood duck hens generally nest within 100 m of wetlands (Girard 1941, Glover 1956, Keith 1961, Bellrose 1980, Robb 1986); however habitat composition within 1 km may not have extended far enough to include other factors influencing habitat use. Duebbert (1968) suggested that mallard hens flew into prime nesting cover from relatively long distances (4.8 - 8.0 km). Likewise, Duebbert and Lokemoen (1976) suggested that idle fields, grasses, and legumes within 1.6 - 3.2 km of wetland complexes provided nesting habitat for waterfowl.

Wetlands on forest preserves were hypothesized to provide higher quality wetland habitats. Semipermanent marshes on forest preserves tended to be less disturbed by urban development and agriculture. Additionally, Canada geese were encouraged to use forest preserves by provision of nesting structures, islands, upland management, and feeding by humans. However, blue-winged teal were the only species with greater pair densities on wetlands in natural areas, forest preserves, and state parks. These results could be attributed to the fact that mallards, Canada geese, and wood ducks were more tolerant of urban environments than blue-winged teal. Heusmann and Burrell (1984) reported that mallards were the most common duck species in urban environments, and it was not unusual to observe wood ducks in urban parks. Figley and Van Druff (1982) reported that mallards readily adapted their behavior to urban environments. Nuisance Canada goose complaints have increased over the last several years in urban and suburban areas of the United States, indicating their tolerance of human interaction (Conover and Chasko 1985, Conover and Kania 1991). Lack of differences in pair densities on protected vs. private wetland for Canada geese, mallards, wood ducks, and total pairs indicated tolerance of human activities rather than lack of preference for high quality wetland habitats.

While most wetlands on forest preserves and state natural areas were high quality habitats, some basins were tiled and/or ditched, thus reducing their quality and enhancing their similarity to private wetlands. Due to the large human population and urban environment of northeastern Illinois, forest preserves are heavily used for outdoor recreation. Altered wetland habitats and human/wildlife interactions could have reduced the attractiveness of wetlands protected on forest preserves, natural areas, and state parks.

Relationships between pair densities on wetlands and surrounding land use have been reported by others (Dwyer 1970, Lokemoen 1973, Duebbert and Kantrud 1974, McEnroe 1976). Kantrud and Stewart (1977) concluded that environmental variables and composition of local wetland complexes influenced use of wetlands by breeding waterfowl. Land use surrounding basins had no measurable association with wetland use by waterfowl broods in Saskatchewan (Stoudt 1971). Mack and Flake (1980) found no significant relationship between mallard broods and area of idle cover surrounding a basin, but mallard broods were negatively associated with area of pasture surrounding a basin. Land use within 1 km of basins was of little value in explaining brood densities on wetlands in northeastern Illinois.

Aquatic Macroinvertebrates.--Availability of aquatic invertebrates is an important factor influencing use of wetlands by breeding waterfowl (Swanson and Duebbert 1989). Waterfowl shift from mainly plant to invertebrate diets as breeding season approaches (Swanson and Meyer 1977; Swanson et al. 1974, 1979, 1985; Drobney and Fredrickson 1979; Wheeler and March 1979; Krapu 1981). The shift in diet reflects nutritional requirements of egg production (McKinney 1986). Invertebrates consumed by breeding dabbling female ducks on temporary and seasonal wetlands are important sources of protein and minerals for egg formation (Krapu 1979, Drobney 1990). Joyner (1980) found that breeding duck use of ponds in Ontario was influenced by diversity and density of aquatic macroinvertebrates. Mallard and blue-winged teal pair densities were strongly correlated with benthic invertebrates in experimental manipulations of a cattail marsh (Murkin et al. 1982). Krull (1970) observed differences in aquatic invertebrate abundance associated with vegetation structure in wetlands. Krull (1970) and Korschgen (1989) reported that aquatic macroinvertebrates were more abundant on vegetated sites. Aquatic plants that do not produce waterfowl foods often harbor large numbers of invertebrates. Because vegetation structure is associated with aquatic macroinvertebrate abundance in wetlands, breeding waterfowl may select wetland habitats based on vegetation cues (Nelson and Kadlec 1984).

Taxonomic diversity of benthic and nektonic macroinvertebrates varied temporally in northeastern Illinois wetlands. However, no differences were detected in densities of benthic and nektonic invertebrate samples among sampling periods. Species structure of invertebrate communities in prairie pothole wetlands in North Dakota undergo seasonal changes (Swanson et al. 1974). Seasonal and temporary wetlands warm earlier and provide invertebrate foods for waterfowl before invertebrate communities develop on more permanent wetlands (Swanson et al. 1974). Murkin et al. (1982) attributed temporal increases in diversity and density of aquatic invertebrates to increases in water temperature.

Benthic invertebrate diversities were greater in ponds and semipermanent marshes than in seasonal and temporary marshes. Although nektonic invertebrate diversity did not differ between basin types, seasonal marshes had greater nektonic densities than temporary marshes. These results differed from Wheeler and March (1979) who found the largest nektonic densities on temporary wetlands, and highest benthic densities on seasonal wetlands.

Benthic invertebrate diversity and density did not differ between vegetated and open water areas of wetlands in northeastern Illinois. However, diversity and density of nektonic invertebrates were greater in vegetated zones. Nektonic invertebrate communities were more in the moist soil-shallow emergent zone than in robust emergent, submergent-floating leaf, and open water areas. Nektonic diversity in robust emergent vegetation was also greater than in open water samples but did not differ from submergent-floating leaf vegetation. Nektonic invertebrate densities were also greater in moist soil-shallow emergent vegetation than in the open water zone. Thus, moist soil-shallow emergent vegetation that harbored the largest and most diverse nektonic invertebrate communities in wetlands was also the most abundant form of aquatic vegetation in northeastern Illinois wetlands. Flooded shallow marsh zones in wetlands were an important factor effecting dabbling duck pair densities in the prairies (Kaminski and Prince 1984). Although wetland use by breeding ducks was reported to be associated with availability of food (Jessen et al. 1964, Swanson and Duebbert 1989), few relationships between breeding pairs or broods and moist soil-shallow emergent vegetation were detected in northeastern Illinois. Invertebrate food resources associated with vegetation zones did not appear to influence wetland use by breeding pairs and broods.

Other authors have reported submergent-floating leaf vegetation associations with invertebrate abundance. Krull (1970) found invertebrate abundance to be much greater in submergent vegetation than open water. Ringelman (1991:24) stated that underwater plants with finely divided leaves should harbor the most numerous supply of invertebrates in wetlands. Duckweed (Lemna spp.) and bladderwort (Utricularia spp.) have also been reported to harbor large numbers of invertebrate food items (Collias and Collias 1963). Collias and Collias (1963) also reported that cattails (Typha spp.) had relatively poor invertebrate populations. However, most of the robust emergent vegetation samples collected in this study were collected in cattail which had favorable invertebrate communities. Voigts (1976) reported submergent vegetation harbored abundant aquatic invertebrates. The comparatively low invertebrate diversity and density observed in submergent-floating leaf vegetation in this study was probably due to the small number of invertebrate samples collected in this vegetation type. However, few significant relationships were detected between waterfowl breeding pairs and broods and submergent-floating leaf vegetation, which may have been due to the lack of submergent-floating leaf vegetation during the early censuses each spring. Invertebrates associated with submergent-floating leaf vegetation may have been more diverse and dense at later dates in spring, thereby harboring an invertebrate food source for renesting hens and broods.

## CONCLUSIONS AND RECOMMENDATIONS

Breeding pair densities in the glaciated pothole region of northeastern Illinois compare favorably with other secondary waterfowl production areas in South Dakota, east-central Wisconsin, northern Ontario, and southern Ontario (Brewster et al. 1976, Wheeler and March 1979, Ross 1987, Dennis 1989). Waterfowl brood densities in northeastern Illinois were low, but comparable to other secondary production areas. Compared to other production areas in North America, waterfowl breeding populations in northeastern Illinois included few species. Mallards and Canada geese comprised the majority of northeastern Illinois waterfowl pair and brood populations; wood ducks and blue-winged teal comprised nearly all of the remaining breeding population.

Wetland habitats of northeastern Illinois could be a population sink for breeding ducks. Although Canada geese had high production as demonstrated by high nest success and productivity index, low mallard and wood duck productivity indices were observed. The mallard productivity index of 0.07 for northeastern Illinois was well below the suggested 15% nest success rate necessary to maintain a stable population an agricultural areas of North Dakota (Cowardin et al. 1985). Mallard brood population estimates were likely low because of limited detectability and lack of late brood surveys that might have detected broods from renest attempts. However, the productivity index was sufficiently low to suggest that mallard production in northeastern Illinois may not compensate for adult mortality. A relatively stable breeding population may be maintained by yearly ingress of pairs from other production areas.

All types of palustrine basins (semipermanent, seasonal, temporary marsh, and pond) were important to breeding waterfowl in northeastern Illinois. The importance of semipermanent and seasonal marshes was indicated by their large contribution to breeding pair and brood population estimates. Seasonal and semipermanent marshes accounted for $\geq$ 63% of the waterfowl breeding pairs on palustrine wetlands during each census. The importance of temporary marshes was indicated by the preference for this wetland type by mallard pairs. High pair and brood densities on ponds, and preference for ponds by mallards pairs indicated the importance of this wetland type. Stream segments were avoided by waterfowl pairs during all censuses, indicating that riparian wetlands were not critical waterfowl breeding habitat in northeastern Illinois.

Breeding waterfowl densities on palustrine wetlands in northeastern Illinois were associated with only a few, very simple physical basin characteristics. Wetland area without regard to presence or absence of surface water was the most important factor determining waterfowl pair use of wetlands. The largest variation in wetland use by mallard, blue-winged teal, and total pairs was accounted for by total basin area, and positive relationships were detected between wetland area and Canada goose and wood duck pairs. Percent inundation of wetland basins with surface water also explained substantial variation in breeding pair densities on palustrine wetland basins. Breeding pair and brood densities were also associated with presence and amount of open water pond habitat. Pond habitats were likely important because they provided small open water areas that are necessary for isolation of breeding pairs, and because their more permanent water regime provided brood habitat when many temporary and seasonal wetlands were dry. Other wetland habitat variables and the composition of land use surrounding wetland basins accounted for little variation in wetland use by waterfowl pairs and broods.

The apparent lack of association of waterfowl densities with vegetation and invertebrate community characteristics does not necessarily indicate that natural vegetation communities and undisturbed wetlands are unimportant to breeding waterfowl in northeastern Illinois. Waterfowl probably select habitats primarily on the basis of physical attributes (i.e. size and isolation of wetlands, availability of nesting habitat), reflecting the need for space and isolation from conspecifics during pre-nesting and nesting (Patterson 1976). As brood rearing season progresses, space becomes less important while the importance of food availability and escape cover increases. Thus, biotic factors become increasingly important in wetland habitat selection as later in the brood rearing season (Patterson 1976) after our wetland surveys were terminated.

## JOB C. Analysis and Report

Objective: To integrate published data and findings from these studies into recommendations for habitat protection, enhancement, and management.

This objective was met in part through annual reporting of findings to Illinois Department of Conservation staff in Quarterly and Annual Performance Reports and this Project Final Report. Original data and copies of all reports are on file at the Cooperative Wildlife Research Laboratory, Southern Illinois University at Carbondale, Carbondale, IL 62901. The following sections present the management implications of this study and general recommendations to guide habitat protection and enhancement activities to benefit waterfowl and wetland resources of northeastern Illinois.

## NON-BREEDING SEASON

Aerial transects flown with a helicopter at 1.6 km intervals effectively surveyed populations of Canada geese, mute swans, and possibly goldeneyes in northeastern Illinois. Although surveyed areas were not entirely contiguous between the breeding and non-breeding season population surveys, numbers of Canada geese observed during the September 1990 aerial survey were below estimates derived from breeding population surveys of selected wetlands and deepwater habitats. Wetland censuses conducted in spring 1990-91 provided a mean estimate of 6,434 breeding adult Canada geese (3,217 breeding pairs) within the 2,870 km $^2$ primary study area. The 3,217 breeding pairs produced a mean of 1,620 broods that averaged 4.9 goslings/brood in May/June. Assuming that non-breeding resident geese left the area to molt (R. A. Williamson, pers. commun.), 14,372 geese (breeding adults and their young) were present in May/June. Aerial surveys conducted mostly within the 2,870 km$^2$ primary study area during September 1990 indicated a post-breeding population of at least 8,985 Canada geese. Some unsuccessful breeding pairs may have departed the region and some juvenile mortality likely occurred between June and September. Consequently, aerial surveys conducted in September and ground surveys of wetlands conducted in May/June indicated a post-breeding population of 9,000 - 14,000 Canada geese over an approximately 3,000 km$^2$ area of northeastern Illinois.

Census data for other waterfowl species should be considered incomplete, reflecting at best variation in distribution and relative abundance. The most complete counts of waterfowl from aerial transects in northeastern Illinois can be obtained after leaf-fall, particularly when cold weather concentrates birds on small areas of open water. More complete counts of mallards and other waterfowl might be obtained if transect intervals were reduced to 0.8 km and flight speed and altitude reduced. However, this was considered impractical due to constraints imposed by urban developments and increased time and cost requirements of more intensive surveys. Based on the distributions of waterfowl observed in the 4 aerial surveys conducted during this study, a stratified system of aerial transects with standardized widths could be designed to obtain statistically valid estimates of wintering geese, swans, and mallards in northeastern Illinois. Since the greatest proportions and densities of waterfowl/km of transect were observed in Cook and DuPage counties, future surveys should be intensified in urban areas and expanded to include areas to the east and south of those surveyed in 1990-91.

Waterfowl distributions were highly associated with urban areas during the non-breeding season. As long as open water is available in proximity to food sources provided by agricultural fields and grass lawns, northeastern Illinois will continue to attract large concentrations of wintering and migrating waterfowl, particularly Canada geese and mallards that readily adapt to urban environments. Enhancement of habitat specifically for wintering and migrating waterfowl is probably not a necessary or perhaps even desirable management alternative in much of northeastern Illinois. Emphasis could be placed on providing roosting, resting, and feeding habitats in outlying rural areas, and on some of the larger forest preserves, state parks, and other public lands in the region. Wetland acquisition and conservation programs should emphasize protection of large semipermanent marshes that remain in rural areas of northeastern Illinois. Consideration should also be given to protecting upland habitats that surround natural wetlands in the region.

## BREEDING SEASON

Northeastern Illinois wetlands support waterfowl breeding pair populations that compare favorably with waterfowl production areas of secondary importance in North America. The region also provides spring migration and breeding habitat for waterfowl that breed farther north, particularly northern shovelers. Although waterfowl breeding pair populations compared favorably with several breeding areas in North America, there was evidence from this study that production of young by mallards and species other than Canada geese was low. Recruitment may not be sufficient to replace annual mortality of breeding adults, and the population may be maintained by ingress of breeding pairs from other production areas. If such is the case, then northeastern Illinois could be a population sink for breeding ducks.

A likely cause of poor production is low nesting success due to predation, abandonment, and/or destruction of nests. There is a lack of secure herbaceous upland nesting habitat in northeastern Illinois, and ducks may be forced to nest near the margins of wetlands or in small isolated patches of residual cover remaining in urban and agricultural environments where they are vulnerable to predation and human disturbance. Wooded habitats and semi-urban areas appear to support large populations of potential nest predators, particularly raccoons (_Procyon_ _lotor_) and skunks (_Mephitis mephitis_). Young broods may also be vulnerable to other mammalian and avian predators as well.

Additional work is needed to obtain more reliable indices of production than were obtained in this study. Our work concentrated primarily on obtaining estimates of breeding pair populations, so wetland surveys were not conducted beyond early brood rearing periods for mallards, wood ducks, and blue-winged teal. Duck brood densities that we observed did not account for late-hatched nests (particularly blue-winged teal) or re-nests, and broods are not as easily detected as breeding pairs. Consequently, our productivity indices (ratios of pairs : broods) were minimum estimates. Canada geese nest early, generally do not renest, and broods are conspicuous so productivity indices were considered more reliable. More intensive and frequent surveys of fewer wetlands extending later into the brood rearing season would provide more accurate productivity indices for mallards, teal, and wood ducks.

High densities of waterfowl and preference for open water ponds observed in this study may indicate a lack of small isolated wetlands and open water areas that are needed by breeding pairs and broods. Many seasonal and semipermanent marshes in northeastern Illinois are heavily vegetated with emergents such as reed canarygrass or cattail that limit their value as habitat for breeding pairs and broods. Vegetation control measures could be used to disrupt emergent vegetation monocultures that have developed in many marshes. This could be accomplished through mechanical cutting and raising water levels of managed marshes or by restoring natural hydrology through removal of drainage systems. Increased water levels during years of high precipitation should tend to eliminate emergents from at least the deeper portions of marshes and promote colonization by muskrats. Measures should also be implemented to monitor and control the spread of purple loosetrife, a vigorous exotic plant that outcompetes native wetland vegetation. This plant was present in many of the marshes that we surveyed.

Habitat conservation efforts should be directed toward protecting and enhancing temporary and seasonal wetlands that surround relatively large semipermanent marshes that have received the most attention in acquisition programs. Buffer areas surrounding wetlands should also be acquired or protected from impacts of agricultural activities and urban development. Additional research is necessary to determine minimum acceptable areas of surrounding upland that should be protected to maintain adequate hydrological, water quality, and wildlife habitat functions of palustrine wetlands in northeastern Illinois.

The greatest opportunities management and enhancement of upland / wetland habitat complexes for waterfowl and other wetland wildlife are within forest preserves, nature preserves, and state parks. Many of these areas include a diversity of wetland types, but pre-existing drainage ditches and tiles still influence the hydrology and vegetation communities of existing wetlands. More natural hydrologic patterns could be restored by plugging and removing old drainage tiles and ditches. Water levels could be also managed by installing water control structures at existing drainage outlets. Upland nesting habitat could be improved by maintaining open areas in dense native prairie or other herbaceous vegetation, although nest predation will likely continue to be a problem for upland nesting species. Artificial nesting structures and islands could be provided for breeding ducks, but unless properly constructed and maintained, they would likely be usurped by Canada geese.

Wetland acquisition and management programs can not be justified solely on the basis of improving habitat conditions for waterfowl in northeastern Illinois. Entire vegetation and animal communities should be considered in protecting and enhancing wetland / upland habitat complexes. Maintenance and enhancement of waterfowl habitat need not conflict with the welfare of threatened and endangered marsh birds, for example, because nearly all species require a diversity of sizes, depths, and types of natural wetlands to complete their annual life cycle. All species will benefit from efforts to protect and enhance the wetland resources of northeastern Illinois. Future research should be directed toward determining the importance and contributions of different wetland types to supporting viable plant and animal communities.

Avian population surveys on selected wetlands of northeastern Illinois should be expanded to randomly sample all wetland types present the region. Surveys conducted annually in multiple seasons are necessary to adequately characterize wetland bird communities of the region. The wetland data base generated from National Wetlands Inventory data and satellite imagery in this study provides the means by which statistically valid wetland surveys could be designed and implemented. Wetlands continue to be lost or degraded through human activity in northeastern Illinois. Systematic annual surveys of wetlands identified by NWI and satellite imagery are needed to monitor wetland status and trends in the region, and to enforce compliance with federal, state, and local laws and policies regulating environmental impacts.

## LITERATURE CITED

Adams, L. W., L. E. Dove, and T. M. Franklin. 1985. Mallard pair and brood use of urban stormwater-control impoundments. Wildl. Soc. Bull. 13:46-51.

Bacon, B. R. 1990. Ground count transects as an index to wood duck numbers in Wisconsin. Pages 213-217 in L. H. Fredrickson, G. V. Burger, S. P. Havera, D. A. Graber, R. E. Kirby, and T. S. Taylor, eds. Proc. 1988 North Am. Wood Duck Symp., St. Louis, MO.

Bartonek, J. C., and J. J. Hickey. 1969. Selective feeding by juvenile diving ducks in summer. Auk 86:4434-457.

Belanger, L., and R. Couture. 1988. Use of man-made ponds by dabbling duck broods. J. Wildl. Manage. 52:718-723.

Bellrose, F. C. 1980. Ducks, geese, and swans of North America. 3rd ed. Stackpole Books, Harrisburg, PA. 504pp.

Bellrose, F. C., T. G. Scott, A. S. Hawkins, and J. B. Low. 1961. Sex ratios and age ratios in North American ducks. Ill. Nat. Hist. Surv. Bull. 27:391-474.

Brakhage, D. H. 1990. Techniques currently used for monitoring wood duck populations. Pages 201-203 in L. H. Fredrickson, G. V. Burger, S. P. Havera, D. A. Graber, R. E. Kirby, and T. S. Taylor, eds. Proc. 1988 North Am. Wood Duck Symp., St. Louis, MO.

Brewster, W. G., J. M. Gates, and L. D. Flake. 1976. Breeding waterfowl populations and their distribution in South Dakota. J. Wildl. Manage. 40:50-59.

Burger, J. 1985. Habitat selection in temperate marsh-nesting birds. Pages 253-281 in M. L. Cody ed. Habitat selection in birds. Academic Press, New York.

Collias, N. E., and E. C. Collias. 1963. Selective feeding by wild ducklings of different species. Wilson Bull. 75:6-14.

Conover, M. R., and G. G. Chaska. 1985. Nuisance Canada goose problems in the eastern United States. Wildl. Soc. Bull. 13:228-33.

Conover, M. R., and G. S. Kania. 1991. Characteristics of feeding sites used by urban-suburban flocks of canada geese in Connecticut. Wildl. Soc. Bull. 19:36-38.

Courcelles, R., and J. Bedard. 1979. Habitat selection by dabbling ducks in the Baie Noire marsh, southwestern Quebec. Can. J. Zool. 57:2230-2238.

Cowardin, L. M. 1982. Some conceptual and semantic problems in wetland classification and inventory. Wildl. Soc. Bull. 10:57-60.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U. S. Fish and Wildl. Serv. FWS/OBS - 79/31. 103 pp.

Cowardin, L. M., D. S. Gilmer, and C. W. Shaiffer. 1985. Mallard recruitment in the agriculture environment of North Dakota. Wildl. Mono. No. 92. 37pp.

Dennis, R. K. 1989. Interim report on waterfowl breeding pair surveys in northern Ontario, 1980-83. Can. Wildl. Serv. Progress Notes. No. 168. 9 pp.

Diem, K. L., and K. H. Lu. 1960. Factors influencing waterfowl censuses in the parklands, Alberta, Canada. J. Wildl. Manage. 24:113-133.

Drewien, R. C., and P. F. Springer. 1969. Ecological relationships of breeding blue-winged teal to prairie potholes. Pages 102-115 in Saskatoon Wetlands Seminar. Can. Wildl. Serv. Rep. Ser. 6.

Drobney, R. D. 1990. Nutritional quality of breeding wood ducks: a synopsis for wetland management. Pages 77-82 in L. H. Fredrickson, G. V. Burger, S. P. Havera, D. A. Graber, R. E. Kirby, and T. S. Taylor, eds. Proc. 1988 North Am. Wood Duck Symp., St. Louis, MO.

Drobney, R. D., and L. H. Fredrickson. 1979. Food selection by wood ducks in relation to breeding status. J. Wildl. Manage. 43:109-120.

Duebbert, H. F. 1968. High nest density and hatching success of ducks on South Dakota CAP land. N. Am. Wildl. Conf. 34:218-228.

Deubbert, H. F., and H. A. Kantrud. 1974. Upland duck nesting related to land use and predator reduction. J. Wildl. Manage. 38:257-265.

Deubbert, H. F., and J. T. Lokemoen. 1976. Duck nesting in fields of undisturbed grass-legume cover. J. Wildl. Manage. 40:39-49.

Dwyer, T. J. 1970. Waterfowl breeding habitat in agricultural and nonagricultural land in Manitoba. J. Wildl. Manage. 34:130-136.

Dwyer, T. J., G. L. Krapu, and D. M. Janke. 1979. Use of prairie pothole habitat by breeding mallards. J. Wildl. Manage. 43:526-531.

Dzubin, A. 1969a. Assessing breeding populations of ducks from ground counts. Pages 178-230 in Saskatoon Wetlands Seminar. Can. Wildl. Serv. Rep. Ser. 6.

Dzubin, A. 1969b. Comments on carrying capacity of small ponds for ducks and possible effects of density on mallard production. Pages 138-160 in Saskatoon Wetlands Seminar. Can. Wildl. Serv. Rep. Ser. 6.

Evans, C. D., and K. E. Black. 1956. Duck production studies on the prairie potholes of South Dakota. U.S. Fish and Wildl. Serv. Spec. Sci. Rep.: Wildl. 32. 59pp.

Fasset, N. C. 1985. A manual of aquatic plants. Univ. of Wisconsin Press, Madison. 405pp.

Figley, W. K., and L. W. Van Druff. 1982. The ecology of urban mallards. Wildl. Monogr. No. 81. 40pp.

Fredrickson, L. H., and T. S. Taylor. 1982. Management of seasonally flooded impoundments for wildlife. U. S. Dept. Interior, Fish and Wildl. Serv. Res. Publ. 148. 30 pp.

Fredrickson, L. H., and D. A. Graber. 1990. Habitat ecology and management. Pages 381- 385 in L. H. Fredrickson, G. V. Burger, S. P. Havera, D. A. Graber, R. E. Kirby, and T. S. Taylor, eds. Proc. 1988 North Am. Wood Duck Symp., St. Louis, MO.

Gates, J. M. 1965. Duck nesting and production on Wisconsin farmlands. J. Wildl. Manage. 29:515-523.

Gilmer, D. S., I. J. Ball, L. W. Cowardin, J. H. Reichmann, and J. P. Tester. 1975. Habitat use and home range of mallards breeding in Minnesota. J. Wildl. Manage. 39:781-789.

Gilmer, D. S., R. E. Kirby, I. J. Ball, and J. H. Reichmann. 1977. Post-breeding activities of mallards and wood ducks in north central Minnesota. J. Wildl. manage. 41:345-259.

Girard, G. L. 1941. The mallard: its management in western Montana. J. Wildl. Manage. 5:233-259.

Glover, F. A. 1956. Nesting and production of blue-winged teal (Anas discors) in northwest Iowa. J. Wildl. Manage. 20:28-46.

Godin, P. R., and D. E. Joyner. 1981. Pond ecology and its influence on mallard use in Ontario, Canada. Wildfowl 32:28-34.

Golet, F. C., and J. S. Larson. 1974. Classification of freshwater wetlands in the glaciated northeast. U.S. Fish and Wildl. Serv. Resour. Publ. 116. Washington, D.C. 56pp.

Gore, J. A. 1978. Evaluation of wildlife habitat in northern Illinois, 1940 vs. 1970. M.S. Thesis. Southern Illinois Univ., Carbondale. 79 pp.

Hammond, M. C. 1969. Notes on conducting waterfowl breeding surveys in the north central states. Pages 238-254 in Saskatoon Wetlands Seminar. Can. Wildl. Serv. Rep. Ser. 6.

Havera, S. P. 1985. Waterfowl of Illinois: their status and management. Ill. Nat. Hist. Surv. Final Report. 752pp.

Heidorn, R. R., W. D. Glass, D. R. Ludwig, and M. A. R. Cole. 1991. Northeastern Illinois wetland survey for endangered and threatened birds: A summary of field data: 1980-1989. Ill Dept. Cons. Natural Heritage Technical Report No. 1. 157pp.

Heitmeyer, M. E. and L. H. Fredrickson. 1990. Abundance and habitat use of wood ducks in Mingo Swamp of southeastern Missouri. Pages 141-151 in L. H. Fredrickson, G. V. Burger, S. P. Havera, D. A. Graber, R. E. Kirby, and T. S. Taylor, eds. Proc. 1988 North Am. Wood Duck Symp., St. Louis, MO.

Heusmann, H. W., and R. Burrell. 1984. Park waterfowl populations in Massachusetts. J. Field Ornithol. 55:89-96.

Hobaugh, W. C., and J. G. Teer. 1981. Waterfowl use characteristics of flood prevention lakes in northcentral Texas. J. Wildl. Manage. 45:16-26.

Hudson, M. S. 1983. Waterfowl production on three age-classes of stock ponds in Montana. J. Wildl. Manage. 47:112-117.

Jackson, D. H., H. H. Prince, and R. A. Bishop. 1985. Influence of drought on mallards breeding in northern Iowa. J. Wildl. Manage. 49:442-448.

Jessen, R. L., J. P. Lindmeier, and R. E. Farmes. 1964. A study of duck nesting and production as related to land use in Mahnomen County, Minnesota. Pages 26-85 in J. B. Moyle, ed. Ducks and land use in Minnesota. Minnesota Dept. Cons. Tech. Bull. No. 8.

Joyner, D. E. 1980. Influence of invertebrates on pond selection by ducks in Ontario. J. Wildl. Manage. 44:700-705.

Kaminski, R. M., and H. H. Prince. 1981. Dabbling duck and aquatic macroinvertebrate responses to manipulated wetland habitat. J Wildl. Manage. 45:1-15.

Kaminski, R. M., and H. H. Prince. 1984. Dabbling duck-habitat associations during spring in Delta Marsh, Manitoba. J. Wildl. Manage. 48:37-50.

Kantrud, H. A., and R. E. Stewart. 1977. Use of Natural basin wetlands by breeding waterfowl in North Dakota. J. Wildl. Manage. 41:243-253.

Keith, L. B. 1961. A study of waterfowl ecology on small impoundments in southeastern Alberta. Wildl. Mono. No. 6. 88pp.

Kelly, S. T., T. J. Blohm, J. P. Bladen, and H. C. Bourne. 1989. Trends in duck populations, 1955-1989. U. S. Fish Wildl. Serv. Off. Migr. Bird Manage. Administrative Report. Unpublished. 10 pp.

Klett, A. T., T. L. Shaffer, and D. H. Johnson. 1988. Duck nesting success in the prairie pothole region. J. Wildl. Manage. 52:431-40.

Koeln, G. T., D. E. Wesley, and P. J. Caldwell. 1988. Ducks Unlimited Wetland Inventory Program. Pages 225-233 in J. Zelazny and J. S. Feierabend, eds. Wetlands: Increasing our wetland resources. Nat. Wildl. Fed. Corp. Council. 363 pp.

Korschgen, C. E. 1989. Riverine and deepwater habitats for diving ducks. Pages 157-180 in L. M. Smith, R. L. Pederson, and R. M. Kaminski eds. Habitat management for migrating and wintering waterfowl in North America. Texas Tech Univ. Press, Lubbock.

Krapu, G. L. 1979. Nutrition of female dabbling ducks during reproduction. Pages 59-70 in T. A. Bookhout, ed. Waterfowl and wetlands - an integrated review. LaCrosse Printing Co., Inc., LaCrosse.

Krapu, G. L. 1981. The role of nutrient reserves in mallard reproduction. Auk 98:29-38.

Krull, J. N. 1970. Aquatic plant-macroinvertebrate associations and waterfowl. J. Wildl, Manage. 34:707-718.

LaGrange, T. G., and J. J. Dinsmore. 1989. Habitat use by mallards during spring migration through central Iowa. J. Wildl. Manage. 53:1076-81.

Lawrence, J. S. 1987. Population ecology of giant Canada geese in west-central Illinois. PhD dissertation. Southern Illinois Univ., Carbondale. 190pp.

Lokemoen, J. T. 1973. Waterfowl production on stock-watering ponds in the northern plains. J. Range Manage. 26:179-184.

Mack, G. D., and L. D. Flake. 1980. Habitat relationships of waterfowl broods on South Dakota stock ponds. J. Wildl. Manage. 44:695-700.

Mason, W. T., and P. P. Yevich. 1967. The use of phloxine B and rose bengal stains to facilitate sorting benthic samples. Trans. Am. Microsc. Soc. 86:221-223.

McEnroe, M. R. 1976. Factors influencing habitat use by breeding waterfowl in South Dakota. M.S. Thesis. South Dakota State Univ, Brookings. 67pp.

McKinney, F. 1965. Spacing and chasing in breeding ducks. Wildfowl Trust Ann. Rep. 16:92-106.

McKinney, F. 1986. Ecological factors influencing the social systems of migratory dabbling ducks. Pages 153-171 _in_ D. I. Rubenstein and P. W. Wrangham, eds. Ecological aspects of social evolution: Birds and mammals. Princeton Univ. Press, Princeton.

Merrit, R. W., and K. W. Cummins. 1984. An introduction to the aquatic insects of North America. 2nd ed. Kendall/Hunt Publishing Co., Dubuque, IA. 722 pp.

Miller, L. D., M. Unverferth, K. Ghormley, and M. P. Skrdla. 1990. A guide to MIPS: its features and applications. MicroImages, Inc. Lincoln, NE. 101 pp.

Mohlenbrock, R. H. 1986. Guide to the vascular flora of Illinois: revised and enlarged edition. Southern Illinois Univ. Press, Carbondale. 507pp.

Mulhern, J. J., T. D. Nudds, and, B. R. Neal. 1985. Wetland selection by mallards and blue-winged teal. Wilson Bull. 97:473-485.

Murkin H. R., and J. A. Kadlec. 1986. Relationships between waterfowl and macroinvertebrate densities in a northern prairie marsh. J. Wildl. Manage. 50:212-217.

Murkin, C. R., and L. C. M. Ross. 1988. Invertebrates. Pages 67-74 _in_ E. J. Murkin and H. R. Murkin, eds. Marsh ecology research program long-term monitoring procedures manual. Delta Waterfowl and Wetlands Research Station, Manitoba, Canada.

Murkin, C. R., R. M. Kaminski, and R. D. Titman. 1982. Responses by dabbling ducks and aquatic invertebrates to an experimentally manipulated cattail marsh. Can. J. Zool. 60:2324-2332.

Murphy, J. M., B. Kessel, and L. J. Vining. 1984. Waterfowl populations and limnologic characteristics of taiga ponds. J. Wildl. Manage. 48:1156-1163.

Neely, R. D., and C. G. Heister, compilers. 1987. The natural resources of Illinois: Introduction and guide. Ill. Nat. Hist. Surv. Spec. Pub. 6. 224 pp.

Nelson, J. W., and J. A. Kadlec. 1984. A conceptual approach to relating habitat structure and macroinvertebrate production in freshwater wetlands. Trans. N. Am. Wildl. Resour. Conf. 49:262-270.

Neu, L. W., C. R. Byers, and J. M. Peek. 1974. A technique for analysis of utilization-availability data. J. Wildl. Manage. 38:541-545.

Oring, L. W. 1964. Behavior and ecology of certain ducks during the postbreeding period. J. Wildl. Manage. 28:223-33.

Patterson. J. H. 1976. The role of environmental heterogeneity in the regulation of duck populations. J. Wildl. Manage. 40:22-32.

Pennak, R. W. 1978. Fresh-water invertebrates of the United States. 2nd ed. John Wiley and Sons, Inc., New York. 803pp.

Pennak, R. W. 1989. Fresh-water invertebrates of the United States: protozoa to mollusca. 3rd ed. John Wiley and Sons, Inc., New York. 628pp.

Perkins, A. 1981. Status of giant Canada geese in west central Illinois. M.S. Thesis. Southern Illinois Univ., Carbondale. 120 pp.

Reynolds, R. E., R. J. Blohm, F. A. Johnson, and J. B. Bortner. 1990. 1990 status of waterfowl and fall flight forecast. U.S. Fish and Wildl. Serv. 43 pp.

Ringelman, J. K. 1991. Evaluating and managing waterfowl habitat. Colorado Div. Wildl. Div. Rep. No. 16. 46pp.

Robb, J. R. 1986. The importance of nesting cavities and brood habitat to wood duck production. M.S. Thesis Ohio State Univ., Columbus. 135pp.

Robb, J. R., and T. A. Bookhout. 1990. Female and juvenile wood duck survival and movements in Indiana. Pages 179-184 in L. H. Fredrickson, G. V. Burger, S. P. Havera, D. A. Graber, R. E. Kirby, and T. S. Taylor, eds. Proc. 1988 North Am. Wood Duck Symp., St. Louis, MO.

Ross, R. K. 1987. Interim report on waterfowl breeding pair surveys in northern Ontario, 1980-83. Can. Wildl. Serv., Progress Notes. No. 168. 9pp.

Ruwaldt, J. J., L. D. Flake, and J. M. Gates. 1979. Waterfowl pair use of natural and man-made wetlands in south Dakota. J. Wildl. Manage. 43:375-383.

SAS Institute, Inc. 1988a. SAS User's Guide: Basics. Version 6.06 ed. SAS Inst. Inc., Cary, NC. 1290 pp.

SAS Institute, Inc. 1988b. SAS/STAT User's Guide Release. 6.06 ed. SAS Inst. Inc., Cary, NC. 1028 pp.

Schwegman, J. E., G. D. Fell, M. Hutchinson, G. Paulson, W. M. Sheperd, and J. White. 1984. Comprehensive plan for the Illinois Nature Preserves System. Part II - The natural divisions of Illinois. Illinois Nature Preserves Commission, Springfield. 32 pp.

Serie, J. R., and G. G. Chasko. 1990. Status of wood ducks in the Atlantic Flyway. Pages 109-113 in L. H. Fredrickson, G. V. Burger, S. P. Havera, D. A. Graber, R. E. Kirby, and T. S. Taylor, eds. Proc. 1988 North Am. Wood Duck Symp., St. Louis, MO.

Shaw, S. P., and C. G. Fredine. 1956. Wetlands of the United States: their extent, and their value for waterfowl and other wildlife. U.S. Dept. of Interior, Fish and Wildl. Serv., Circular 39. Washington D.C. 67pp.

Smith, A.G. 1971. Ecological factors affecting waterfowl production in the Alberta parklands. U.S. Fish and Wildl. Serv. Resour. Pub. 98. 49pp.

Smith, R. L., and L. D. Flake. 1985. Movements and habitats of brood rearing wood ducks on a prairie river. J. Wildl. Manage. 49:437-42.

Southern, W. E., M. W. Brown, T. L. Houchens, and L. K. Southern. 1981. Northeastern Illinois wetland inventory: Cook, DuPage, Kane, Lake, and McHenry counties. Northern Illinois University, Dekalb. Final Project Report to the Ill. Dept. of Cons., Div. For. Resour. and Nat. Her. 6 vols.

Steel, R. G. D., and J. H. Torrie. 1960. Principles and procedures of statistics. McGraw Hill Book Co., New York, NY. 481 pp.

Stewart, R. E., and H. A. Kantrud. 1971. Classification of natural ponds and lakes in the glaciated prairie region. U.S. Fish and Wildl. Serv. Res. Pub. 92. 57pp.

Stewart, R. E., and H. A. Kantrud. 1972. Population estimates of breeding birds in North Dakota. Auk 89:766-788.

Stewart, R. E., and H. A. Kantrud. 1974. Breeding waterfowl population in the prairie pothole region of North Dakota. Condor 76:70-79.

Stoudt, J. H. 1969. Relationships between waterfowl and water areas on the Redvers waterfowl study area. Pages 123-31 in Saskatoon wetlands seminar. Canadian Wildl. Serv. Rep. Ser. 6.

Stoudt, J. H. 1971. Ecological factors affecting waterfowl production in the Saskatchewan parklands. U.S. Fish and Wildl. Serv. Resour. Pub. 99. 58 pp.

Swanson, G. A. 1978. A simple lightweight core sampler for quantitating waterfowl foods. J. Wildl. Manage. 42:426-428.

Swanson, G. A. 1983. Benthic sampling for waterfowl foods in emergent vegetation. J. Wildl. Manage. 47:821-823.

Swanson, G. A., and M. I. Meyer. 1977. Impact of fluctuating water levels on feeding ecology of breeding blue-winged teal. J. Wildl. Manage. 41:426-433.

Swanson, G. A., and H. F. Duebbert. 1989. Wetland habitats of waterfowl in the prairie pothole region. Pages 228-267 in A. Van Der Valk ed. Northern prairie wetlands. Iowa State Univ. Press, Ames.

Swanson, G. A., H. F. Deubbert, and J. R. Serie. 1974. Feeding ecology of breeding blue-winged teal. J. Wildl. Manage. 38:396-407.

Swanson, G. A., G. L. Krapu, and J. R. Serie. 1979. Foods of laying female dabbling ducks on the breeding grounds. Pages 47-57 in T. A. Bookhout, ed. Waterfowl and wetlands - an integrated review. LaCrosse Printing, Co., Inc. LaCrosse.

Swanson, G. A., M. I. Meyer, and V. A. Adomaitis. 1985. Foods consumed by breeding mallards on wetlands of south-central North Dakota. J. Wildl. Manage. 49:197-203.

Titman, R. D. 1983. Spacing and three bird flights of mallards breeding in pothole habitat. Can. J. Zool. 61:839-847.

U.S. Dept. of Commerce, Bureau of the Census. 1990. Census of Population and Housing: summary tape file 1A. Washington, DC.

U.S. Fish and Wildlife Service. 1990. Wetlands: Meeting the President's Challenge. U.S. Government Printing Office, Washington, DC. 20402. 64pp.

U.S. Fish and Wildlife Service, and Can. Wildl. Serv. 1987. Standard operating procedures for aerial waterfowl breeding ground population and habitat surveys in North America. U.S. Fish and Wildl. Serv., Washington, D.C.; and Can. Wildl. Serv., Ottawa, Ontario. 93pp.

Voigts, D. K. 1976. Aquatic invertebrate abundance in relation to changing marsh vegetation. Am. Midl. Nat. 95:313-322.

Welch, P. S. 1948. Limnological methods. Blakiston Co., Philadelphia. 381pp.

Weller, M. W. 1979. Density and habitat relationships of blue-winged teal nesting in northwestern Iowa. J. Wildl. manage. 43:367-374.

Weller, M. W., and C. E. Spatcher. 1965. Role of habitat in the distribution and abundance of marsh birds. Agric. Home Econ. Exp. Stn. Spec. Rep. 43. 31 pp.

Wheeler, W. E., and J. R. March. 1979. Characteristics of scattered wetlands in relation to duck production in southeastern Wisconsin. Wis. Dept. Nat. Resour. Tech. Bull. 116. 61 pp.

Willman, H. B., and J. C. Frye. 1970. Pleistocene stratigraphy of Illinois. Ill. State Geol. Surv. Bull. 94. 204 pp.

# APPENDIXES

Appendix A. Breeding and nonbreeding waterfowl observed in northeastern Illinois wetlands during springs 1990-91.

| Common name | Scientific name |
|---|---|
| mute swan | *Cygnus olor* |
| Canada goose | *Branta canadensis* |
| American wigeon | *Anas americana* |
| gadwall | *Anas strepera* |
| American green-winged teal | *Anas crecca* |
| mallard | *Anas platyrhynchos* |
| black duck | *Anas rubripes* |
| northern pintail | *Anas acuta* |
| blue-winged teal | *Anas discors* |
| northern shoveler | *Anas clypeata* |
| canvasback | *Aythya valisneria* |
| redhead | *Aythya americana* |
| ring-necked duck | *Aythya collaris* |
| lesser scaup | *Aythya affinis* |
| bufflehead | *Aythya clangula* |
| hooded merganser | *Lophodytes cucullatus* |
| red-breasted merganser | *Mergus serrator* |
| common merganser | *Mergus meganser* |
| ruddy duck | *Oxyura jamaicensis* |

## Appendix B. Plant species used to distinguish vegetation zones in wetlands.

| Common name | Scientific name |
|---|---|
| *Moist Soil - Shallow Emergent* | |
| water plantain | *Alisma plantago-aquatica* |
| pigweed (water hemp) | *Amaranthus ambigens* |
| ragweed | *Ambrosia* spp. |
| swamp milkweed | *Asclepias incarnata* |
| aster | *Aster* spp. |
| Devil's beggarticks | *Bidens frondosa* |
| false nettle | *Boehmeria cylindrica* |
| sea rocket | *Cakile edentula* |
| water hemlock | *Cicuta maculata* |
| stout woodreed | *Cina arundicacea* |
| chufa | *Cyperus esculentus* |
| straw colored sedge | *Cyperus strigosus* |
| three-way sedge | *Dulichium arundinaceum* |
| wild millet | *Echinochloa muricata* |
| Walter's millet | *Echinochloa walteri* |
| marsh spikerush | *Eleocharis palustris* |
| nodding wild rye | *Elymus canadensis* |
| horsetail | *Equisetum* spp. |
| bedstraw | *Galium* spp. |
| fringed gentian | *Gentiana crinita* |
| fowl mannagrass | *Glyceria striata* |
| iris | *Iris* spp. |
| rice cutgrass | *Leersia oryzoides* |
| water parslane | *Ludwigia palustris* |
| water horehound | *Lycopus americanus* |
| watercress | *Nasturtium officinale* |
| switch grass | *Panicum virgatum* |
| arrow arum | *Peltandra virginica* |
| reed canarygrass | *Phalaris arundinacea* |
| smartweeds | *Polygonum* spp. |
| pickerelweed | *Pontederia cordata* |
| shrubby cinquefoil | *Potentilla fruticosa* |
| swamp buttercup | *Ranunculus septentrionalis* |
| swamp rose | *Rosa palustris* |
| curly dock | *Rumex crispus* |
| arrowhead | *Sagittaria* spp. |
| goldenrod | *Solidago* spp. |
| cordgrass | *Spartina pectinata* |
| skunk cabbage | *Symplocarpus foetidus* |
| poison sumac | *Toxicodendron vernix* |
| stinging nettle | *Urtica dioica* |
| cocklebur | *Xanthium* spp. |

Appendix B. Continued.

| Common name | Scientific name |
|---|---|
| *Robust Emergent* | |
| buttonbush | *Cephalanthus occidentalis* |
| purple loosestrife | *Lythrum Salicaria* |
| reed grass | *Phragmites* spp. |
| willow | *Salix* spp. |
| hardstem bulrush | *Scirpus acutus* |
| woolgrass | *Scirpus cyperinus* |
| river bulrush | *Scirpus fluviatilis* |
| softstem bulrush | *Scirpus paludosus* |
| narrow-leaf cattail | *Typha angustifolia* |
| broad-leaf cattail | *Typha latifolia* |
| burreed | *Sparganium* spp. |
| *Submergent - Floating Leaf* | |
| mosquito fern | *Azolla* spp. |
| water shield | *Brasenia schreberi* |
| cabomba | *Cabonba caroliniana* |
| coontail | *Ceratophyllum demersum* |
| chara | *Chara vulgaris* |
| filamentous algae | *Cladolphora* spp. |
| American elodea | *Elodea canadensis* |
| creeping water primrose | *Jussiaea repens* |
| duckweed | *Lemna spp.* |
| frogbit | *Limnobium spongia* |
| water milfoil | *Myriophyllum* spp. |
| naiad | *Najas* spp. |
| American lotus | *Nelumbo lutea* |
| nitella | *Nitella* spp. |
| spatterdock | *Nuphar luteum* |
| white water lily | *Nymphaea tuberosa* |
| pondweeds | *Potamogeton* spp. |
| slender riccia | *Ricciocarpus natans* |
| wigeon grass | *Ruppia maritima* |
| bladderwort | *Utricularia vulgaris* |
| watermeal | *Wolffia* spp. |

Appendix C. Continued.

| Invertebrate Taxa | Wetland Basin Type | | | |
|---|---|---|---|---|
| | Pond | Semipermanent Marsh | Seasonal Marsh | Temporary Marsh |
| Hymenoptera | | | | |
| Pompilidae | - | - | - | - |
| Unknown | - | - | - | - |
| Odonata | | | | |
| Aeshnidae | - | - | - | - |
| Cordulegasteridae | - | - | - | - |
| Lestidae | - | - | - | - |
| Coenagrionidae | - | - | - | - |
| Hemiptera | | | | |
| Ciccadellidae | - | - | - | - |
| Hebridae | - | - | - | - |
| Mesoveliidae | - | - | - | - |
| Gerridae | - | - | - | - |
| Veliidae | - | - | - | - |
| Notonectidae | - | - | - | - |
| Pleidae | - | - | - | - |
| Nepidae | - | - | - | - |
| Belostomatidae | - | - | - | - |
| Corixidae | 0.2 | - | - | - |
| Unknown | - | - | - | - |
| Megaloptera | - | - | - | - |
| Trichoptera | | | | |
| Lepidostomatidae | - | - | - | - |
| Odontoceridae | - | - | - | - |
| Polycentropodidae | - | - | - | - |
| Unknown | - | - | 1.3 | - |

Appendix C. Continued.

| Invertebrate Taxa | Wetland Basin Type | | | |
|---|---|---|---|---|
| | Pond | Semipermanent Marsh | Seasonal Marsh | Temporary Marsh |
| Coleoptera | | | | |
| Haliplidae | - | - | - | - |
| Dytiscidae | - | 0.5 | - | - |
| Elmidae | - | - | - | - |
| Coccinellidae | - | - | - | - |
| Chrysomelidae | - | - | - | - |
| Curculionidae | - | - | - | - |
| Unknown | 0.5 | - | - | - |
| Diptera | | | | |
| Tipulidae | - | - | - | - |
| Psychodidae | - | - | 1.3 | - |
| Dixidae | - | - | - | - |
| Culicidae | - | - | - | - |
| Chaoboridae | - | 2.8 | - | - |
| Chironomidae | | | | |
| Tanypodinae | 0.5 | 0.9 | - | - |
| Other | 2.8 | 7.0 | - | - |
| Heleidae | 0.9 | 0.9 | - | - |
| Stratiomyidae | - | - | - | - |
| Tabananidae | - | - | - | - |
| Sciomyzidae | - | - | - | - |
| Ephydridae | - | - | - | - |
| Anthomyiidae | - | - | - | - |
| Unknown | - | 0.9 | 2.6 | - |

Appendix C. Continued.

| Invertebrate Taxa | Wetland Basin Type | | | |
|---|---|---|---|---|
| | Pond | Semipermanent Marsh | Seasonal Marsh | Temporary Marsh |
| Mollusca | | | | |
| Gastropoda | | | | |
| Physidae | 0.7 | - | - | - |
| Lymnaeidae | 0.5 | 1.4 | - | - |
| Planorbidae | 0.2 | - | - | - |
| Unknown | - | - | 1.3 | - |
| Pelecypoda | | | | |
| Sphaeriidae | 0.9 | 1.4 | 1.3 | - |
| Unknown | - | - | - | - |
| Unknown | - | 0.9 | - | - |
| Total organisms | 426 | 213 | 78 | 8 |

Trace = less than 0.1 %

Appendix D. Percent composition (number of organisms) of aquatic invertebrate taxa by wetland basin type collected in net sweep samples from 15 - 18 April 1990 (sampling period I) in northeastern Illinois.

| Invertebrate Taxa | Wetland Basin Type | | | |
|---|---|---|---|---|
| | Pond | Semipermanent Marsh | Seasonal Marsh | Temporary Marsh |
| Protozoa | | | | |
| Testacida | - | - | - | - |
| Unknown | - | - | - | - |
| Coelenterata | | | | |
| Hydridae | 1.7 | - | - | - |
| Turbellaria | | | | |
| Planaridae | - | - | - | - |
| Rotifera | Trace | 2.7 | - | - |
| Nematoda | 1.1 | - | 0.8 | 1.9 |
| Annelida | | | | |
| Oligochaeta | | | | |
| Aquatic | 1.8 | 1.4 | 1.6 | 1.9 |
| Terrestrial | - | Trace | - | - |
| Hirudinea | - | Trace | - | - |
| Arthropoda | | | | |
| Crustacea | | | | |
| Anostraca | | | | |
| Chirocephalidae | 0.7 | 0.4 | 3.4 | - |

Appendix D. Continued.

| Invertebrate Taxa | Wetland Basin Type<br>Pond | <br>Semipermanent Marsh | <br>Seasonal Marsh | <br>Temporary Marsh |
|---|---|---|---|---|
| Conchostraca | 0.7 | 1.3 | 0.1 | 1.9 |
| Cladocera | 64.7 | 37.2 | 75.5 | 7.4 |
| Copepoda | 21.8 | 40.1 | 13.5 | 81.5 |
| Ostracoda | 4.1 | 8.9 | 0.5 | - |
| Chilopoda | - | - | - | - |
| Isopoda | | | | |
| Asellidae | 0.5 | 1.8 | Trace | 1.9 |
| Amphipoda | | | | |
| Talitridae | Trace | - | - | - |
| Gammaridae | 0.1 | 0.4 | - | - |
| Decapoda | | | | |
| Astacidae | - | - | - | - |
| Hydracarina | | | | |
| Hydracnidae | Trace | Trace | Trace | - |
| Insecta | | | | |
| Collembola | | | | |
| Isotomidae | Trace | Trace | Trace | - |
| Plecoptera | | | | |
| Nemouridae | - | - | - | - |
| Perlodidae | - | - | - | - |
| Unknown | - | - | - | - |
| Ephemeroptera | | | | |
| Baetidae | Trace | - | - | - |
| Caenidae | 0.1 | - | - | - |
| Unknown | - | - | - | - |

Appendix D. Continued.

| Invertebrate Taxa | Wetland Basin Type | | | |
|---|---|---|---|---|
| | Pond | Semipermanent Marsh | Seasonal Marsh | Temporary Marsh |
| Hymenoptera | | | | |
| Pompilidae | - | - | - | - |
| Unknown | - | - | - | - |
| Odonata | | | | |
| Aeshnidae | - | - | Trace | - |
| Cordulegasteridae | - | - | - | - |
| Lestidae | Trace | Trace | - | - |
| Coenagrionidae | - | - | - | - |
| Hemiptera | | | | |
| Ciccadellidae | - | - | - | - |
| Hebridae | - | - | - | - |
| Mesoveliidae | - | - | - | - |
| Gerridae | - | - | - | - |
| Veliidae | - | - | - | - |
| Notonectidae | - | - | Trace | - |
| Pleidae | - | - | - | - |
| Nepidae | - | - | - | - |
| Belostomatidae | - | - | - | - |
| Corixidae | 0.1 | Trace | Trace | 1.9 |
| Unknown | - | - | - | - |
| Megaloptera | - | - | - | - |
| Trichoptera | | | | |
| Lepidostomatidae | - | Trace | Trace | - |
| Odontoceridae | - | - | - | - |
| Polycentropodidae | - | - | 0.1 | - |
| Unknown | - | 0.1 | - | - |

Appendix D. Continued.

| Invertebrate Taxa | Wetland Basin Type | | | |
|---|---|---|---|---|
| | Pond | Semipermanent Marsh | Seasonal Marsh | Temporary Marsh |
| Coleoptera | | | | |
| Haliplidae | - | Trace | - | - |
| Dytiscidae | Trace | 0.2 | Trace | - |
| Elmidae | - | - | - | - |
| Coccinellidae | - | - | - | - |
| Chrysomelidae | - | - | - | - |
| Curculionidae | - | - | - | - |
| Unknown | - | - | - | - |
| Diptera | | | | |
| Tipulidae | - | - | - | - |
| Psychodidae | Trace | - | - | - |
| Dixidae | - | - | - | - |
| Culicidae | Trace | 0.1 | 1.6 | - |
| Chaoboridae | 0.3 | 1.0 | Trace | - |
| Chironomidae | | | | |
| Tanypodinae | Trace | 0.1 | 0.1 | - |
| Other | 1.1 | 2.5 | 1.1 | - |
| Heleidae | - | 0.1 | - | - |
| Stratiomyidae | Trace | - | Trace | - |
| Tabananidae | - | - | - | - |
| Sciomyzidae | - | - | Trace | - |
| Ephydridae | - | - | - | - |
| Anthomyiidae | - | - | - | - |
| Unknown | Trace | 0.1 | Trace | - |

Appendix D. Continued.

| Invertebrate Taxa | Wetland Basin Type | | | |
|---|---|---|---|---|
| | Pond | Semipermanent Marsh | Seasonal Marsh | Temporary Marsh |
| Mollusca | | | | |
| Gastropoda | | | | |
| Physidae | Trace | 0.1 | Trace | - |
| Lymnaeidae | Trace | 0.6 | Trace | - |
| Planorbidae | 0.2 | 0.5 | 1.0 | 1.9 |
| Unknown | Trace | 0.1 | - | - |
| Pelecypoda | | | | |
| Sphaeriidae | 0.3 | 0.3 | 0.1 | - |
| Unknown | - | - | - | - |
| Unknown | Trace | 0.1 | 0.1 | - |
| Total organisms | 6719 | 5705 | 5063 | 54 |

Trace = less than 0.1 %

Appendix E. Percent composition (number of organisms) of aquatic invertebrate taxa by wetland basin type collected in benthic core samples from 8 - 10 May 1990 (sampling period II) in northeastern Illinois.

| Invertebrate Taxa | Wetland Basin Type | | | |
|---|---|---|---|---|
| | Pond | Semipermanent Marsh | Seasonal Marsh | Temporary Marsh |
| Protozoa | | | | |
| Testacida | 2.1 | 1.6 | - | 2.0 |
| Unknown | - | - | - | - |
| Coelenterata | | | | |
| Hydridae | - | - | - | - |
| Turbellaria | | | | |
| Planaridae | 3.7 | - | - | - |
| Rotifera | - | 0.6 | - | - |
| Nematoda | 3.7 | 1.6 | 3.0 | 4.0 |
| Annelida | | | | |
| Oligochaeta | | | | |
| Aquatic | 37.9 | 23.8 | 78.0 | 32.0 |
| Terrestrial | 1.6 | 1.3 | 3.0 | - |
| Hirudinea | 1.6 | 1.3 | - | - |
| Arthropoda | | | | |
| Crustacea | | | | |
| Anostraca | | | | |
| Chirocephalidae | - | - | - | - |

Appendix E. Continued.

| Invertebrate Taxa | Wetland Basin Type | | | |
|---|---|---|---|---|
| | Pond | Semipermanent Marsh | Seasonal Marsh | Temporary Marsh |
| Conchostraca | 0.3 | 1.3 | 1.0 | - |
| Cladocera | 18.1 | 22.8 | 1.0 | - |
| Copepoda | 3.7 | 17.4 | 1.0 | - |
| Ostracoda | 0.5 | 5.1 | 4.0 | - |
| Chilopoda | - | - | - | - |
| Isopoda | | | | |
| Asellidae | 7.4 | 5.5 | - | - |
| Amphipoda | | | | |
| Talitridae | 0.3 | - | - | - |
| Gammaridae | 0.8 | 0.3 | - | - |
| Decapoda | | | | |
| Astacidae | - | - | - | - |
| Hydracarina | | | | |
| Hydracnidae | - | - | - | - |
| Insecta | | | | |
| Collembola | | | | |
| Isotomidae | - | - | 2.0 | - |
| Plecoptera | | | | |
| Nemouridae | - | - | - | - |
| Perlodidae | - | - | - | - |
| Unknown | - | - | - | - |
| Ephemeroptera | | | | |
| Baetidae | - | - | - | - |
| Caenidae | 3.5 | - | - | - |
| Unknown | - | - | - | - |

Appendix E. Continued.

| Invertebrate Taxa | Wetland Basin Type |  |  |  |
|---|---|---|---|---|
|  | Pond | Semipermanent Marsh | Seasonal Marsh | Temporary Marsh |
| Hymenoptera |  |  |  |  |
| Pompilidae | - | - | - | - |
| Unknown | - | - | - | - |
| Odonata |  |  |  |  |
| Aeshnidae | - | - | - | - |
| Cordulegasteridae | - | - | - | - |
| Lestidae | - | - | - | - |
| Coenagrionidae | - | - | - | - |
| Hemiptera |  |  |  |  |
| Ciccadellidae | - | - | - | - |
| Hebridae | - | - | - | - |
| Mesoveliidae | - | - | - | - |
| Gerridae | - | - | - | - |
| Veliidae | - | - | - | - |
| Notonectidae | - | - | - | - |
| Pleidae | - | - | - | - |
| Nepidae | - | - | - | - |
| Belostomatidae | - | - | - | - |
| Corixidae | - | - | - | - |
| Unknown | - | - | - | - |
| Megaloptera | - | - | - | - |
| Trichoptera |  |  |  |  |
| Lepidostomatidae | - | - | - | - |
| Odontoceridae | - | - | - | - |
| Polycentropodidae | - | - | - | - |
| Unknown | - | - | - | - |

Appendix E. Continued.

| Invertebrate Taxa | Wetland Basin Type | | | |
|---|---|---|---|---|
| | Pond | Semipermanent Marsh | Seasonal Marsh | Temporary Marsh |
| Coleoptera | | | | |
| Haliplidae | - | - | - | - |
| Dytiscidae | 0.8 | - | - | 2.0 |
| Elmidae | - | - | - | - |
| Coccinellidae | - | - | - | - |
| Chrysomelidae | - | - | - | - |
| Curculionidae | - | - | - | - |
| Unknown | - | - | - | - |
| Diptera | | | | |
| Tipulidae | - | - | - | 6.0 |
| Psychodidae | - | - | - | - |
| Dixidae | - | - | - | - |
| Culicidae | - | 0.3 | - | - |
| Chaoboridae | 0.5 | 0.3 | - | - |
| Chironomidae | | | | |
| Tanypodinae | 0.3 | 1.0 | - | - |
| Other | 8.0 | 12.2 | 5.0 | 36.0 |
| Heleidae | 0.8 | 0.3 | - | - |
| Stratiomyidae | - | 1.3 | 1.0 | - |
| Tabananidae | - | - | - | - |
| Sciomyzidae | - | - | - | - |
| Ephydridae | - | - | - | - |
| Anthomyiidae | - | - | - | - |
| Unknown | 0.5 | - | 1.0 | - |

Appendix E. Continued.

| Invertebrate Taxa | Wetland Basin Type | | | |
|---|---|---|---|---|
| | Pond | Semipermanent Marsh | Seasonal Marsh | Temporary Marsh |
| Mollusca | | | | |
| Gastropoda | | | | |
| Physidae | 0.3 | - | - | - |
| Lymnaeidae | - | - | - | - |
| Planorbidae | 0.8 | - | - | - |
| Unknown | 0.8 | 0.3 | - | - |
| Pelecypoda | | | | |
| Sphaeriidae | 1.3 | 0.3 | - | - |
| Unknown | - | 0.3 | - | - |
| Unknown | 0.5 | 1.0 | - | 18.0 |
| Total organisms | 375 | 311 | 100 | 50 |

Trace = less than 0.1 %

Appendix F. Percent composition (number of organisms) of aquatic invertebrate taxa by wetland basin type collected in nektonic samples from 8 - 10 May 1990 (sampling period II) in northeastern Illinois.

| Invertebrate Taxa | Wetland Basin Type | | | |
|---|---|---|---|---|
| | Pond | Semipermanent Marsh | Seasonal Marsh | Temporary Marsh |
| Protozoa | | | | |
| Testacida | 1.5 | - | - | - |
| Unknown | - | - | - | - |
| Coelenterata | | | | |
| Hydridae | 0.3 | 0.2 | - | 0.3 |
| Turbellaria | | | | |
| Planaridae | - | - | - | - |
| Rotifera | 1.9 | 0.3 | 0.1 | - |
| Nematoda | 1.0 | 0.1 | Trace | 0.8 |
| Annelida | | | | |
| Oligochaeta | | | | |
| Aquatic | 5.1 | 1.3 | 0.3 | 2.6 |
| Terrestrial | - | - | - | - |
| Hirudinea | - | - | - | - |
| Arthropoda | | | | |
| Crustacea | | | | |
| Anostraca | | | | |
| Chirocephalidae | Trace | 0.2 | Trace | - |

Appendix F. Continued.

| Invertebrate Taxa | Wetland Basin Type | | | |
|---|---|---|---|---|
| | Pond | Semipermanent Marsh | Seasonal Marsh | Temporary Marsh |
| Conchostraca | 0.2 | 3.4 | 0.8 | - |
| Cladocera | 63.2 | 47.4 | 26.3 | 33.1 |
| Copepoda | 19.1 | 6.2 | 6.3 | 11.6 |
| Ostracoda | 0.6 | 22.5 | 54.9 | 18.3 |
| Chilopoda | - | - | - | - |
| Isopoda | | | | |
| Asellidae | 1.4 | 4.3 | Trace | 9.0 |
| Amphipoda | | | | |
| Talitridae | Trace | - | - | - |
| Gammaridae | 0.4 | 1.4 | - | 1.6 |
| Decapoda | | | | |
| Astacidae | - | - | - | - |
| Hydracarina | | | | |
| Hydracnidae | Trace | Trace | Trace | 0.3 |
| Insecta | | | | |
| Collembola | | | | |
| Isotomidae | - | Trace | 0.1 | - |
| Plecoptera | | | | |
| Nemouridae | - | - | - | - |
| Perlodidae | - | Trace | - | - |
| Unknown | - | - | - | - |
| Ephemeroptera | | | | |
| Baetidae | - | - | - | - |
| Caenidae | 0.3 | Trace | - | - |
| Unknown | - | - | - | - |

Appendix F. Continued.

| Invertebrate Taxa | Wetland Basin Type | | | |
|---|---|---|---|---|
| | Pond | Semipermanent Marsh | Seasonal Marsh | Temporary Marsh |
| Hymenoptera | | | | |
| Pompilidae | - | Trace | - | - |
| Unknown | - | - | - | - |
| Odonata | | | | |
| Aeshnidae | - | - | - | - |
| Cordulegasteridae | - | - | - | - |
| Lestidae | Trace | 0.2 | 0.6 | - |
| Coenagrionidae | - | - | - | - |
| Hemiptera | | | | |
| Ciccadellidae | - | - | - | - |
| Hebridae | Trace | - | - | - |
| Mesoveliidae | - | - | - | - |
| Gerridae | - | - | - | - |
| Veliidae | - | - | Trace | - |
| Notonectidae | - | - | - | - |
| Pleidae | 0.1 | - | - | - |
| Nepidae | - | - | - | - |
| Belostomatidae | - | - | - | - |
| Corixidae | Trace | 0.1 | - | - |
| Unknown | - | Trace | - | - |
| Megaloptera | - | - | - | - |
| Trichoptera | | | | |
| Lepidostomatidae | - | - | - | - |
| Odontoceridae | - | 0.9 | - | - |
| Polycentropodidae | - | - | - | - |
| Unknown | Trace | Trace | Trace | 0.3 |

Appendix F. Continued.

| Invertebrate Taxa | Wetland Basin Type | | | |
|---|---|---|---|---|
| | Pond | Semipermanent Marsh | Seasonal Marsh | Temporary Marsh |
| Coleoptera | | | | |
| Haliplidae | - | Trace | - | - |
| Dytiscidae | Trace | 0.3 | 0.1 | 0.5 |
| Elmidae | - | Trace | Trace | - |
| Coccinellidae | - | - | Trace | - |
| Chrysomelidae | - | - | - | - |
| Curculionidae | Trace | - | - | - |
| Unknown | - | Trace | - | - |
| Diptera | | | | |
| Tipulidae | Trace | Trace | Trace | - |
| Psychodidae | Trace | - | - | - |
| Dixidae | - | - | - | - |
| Culicidae | Trace | 0.2 | 7.8 | 4.5 |
| Chaoboridae | 1.1 | 2.1 | 0.2 | 0.5 |
| Chironomidae | | | | |
| Tanypodinae | 0.3 | 0.1 | Trace | - |
| Other | 2.6 | 3.2 | 1.6 | 16.4 |
| Heleidae | 0.1 | - | - | - |
| Stratiomyidae | Trace | 0.1 | Trace | - |
| Tabananidae | - | - | - | - |
| Sciomyzidae | - | - | - | - |
| Ephydridae | Trace | Trace | - | - |
| Anthomyiidae | - | Trace | - | - |
| Unknown | - | Trace | 0.2 | - |

Appendix F. Continued.

| Invertebrate Taxa | Wetland Basin Type | | | |
|---|---|---|---|---|
| | Pond | Semipermanent Marsh | Seasonal Marsh | Temporary Marsh |
| Mollusca | | | | |
| Gastropoda | | | | |
| Physidae | 0.2 | 3.1 | - | - |
| Lymnaeidae | 0.1 | 0.7 | Trace | - |
| Planorbidae | 0.3 | 0.9 | Trace | 0.3 |
| Unknown | 0.1 | 0.8 | - | - |
| Pelecypoda | | | | |
| Sphaeriidae | 0.3 | 0.2 | 0.4 | - |
| Unknown | - | - | - | - |
| Unknown | Trace | Trace | Trace | - |
| Total organisms | 18,610 | 28,149 | 6,246 | 378 |

Trace = less than 0.1 %

Appendix G. Percent composition (number of organisms) of aquatic invertebrate taxa by wetland basin type collected in nektonic samples from 26 - 27 April 1991 (sampling period III) in northeastern Illinois.

| Invertebrate Taxa | Wetland Basin Type<br>Pond | <br>Semipermanent Marsh | <br>Seasonal Marsh | <br>Temporary Marsh |
|---|---|---|---|---|
| Protozoa | | | | |
| Testacida | 1.5 | 0.1 | Trace | 1.1 |
| Unknown | - | - | - | - |
| Coelenterata | | | | |
| Hydridae | - | - | - | - |
| Turbellaria | | | | |
| Planaridae | Trace | - | - | - |
| Rotifera | 0.2 | 0.6 | Trace | 0.1 |
| Nematoda | Trace | - | - | 3.2 |
| Annelida | | | | |
| Oligochaeta | | | | |
| Aquatic | 1.9 | 1.5 | 0.1 | 0.8 |
| Terrestrial | - | - | - | - |
| Hirudinea | Trace | Trace | Trace | - |
| Arthropoda | | | | |
| Crustacea | | | | |
| Anostraca | | | | |
| Chirocephalidae | Trace | 0.2 | Trace | Trace |

Appendix G. Continued.

| Invertebrate Taxa | Wetland Basin Type | | | |
|---|---|---|---|---|
| | Pond | Semipermanent Marsh | Seasonal Marsh | Temporary Marsh |
| Conchostraca | 0.1 | - | 22.9 | Trace |
| Cladocera | 61.5 | 35.9 | 11.3 | 54.2 |
| Copepoda | 8.9 | 14.8 | 11.1 | 10.4 |
| Ostracoda | 23.0 | 33.4 | 53.0 | 23.2 |
| Chilopoda | - | Trace | - | - |
| Isopoda | | | | |
| Asellidae | 0.1 | 6.7 | Trace | 0.4 |
| Amphipoda | | | | |
| Talitridae | Trace | - | Trace | - |
| Gammaridae | 0.2 | 0.2 | Trace | 0.1 |
| Decapoda | | | | |
| Astacidae | - | Trace | - | - |
| Hydracarina | | | | |
| Hydracnidae | 0.3 | 0.3 | Trace | 0.6 |
| Insecta | | | | |
| Collembola | | | | |
| Isotomidae | - | 0.1 | Trace | - |
| Plecoptera | | | | |
| Nemouridae | - | - | - | Trace |
| Perlodidae | - | - | - | - |
| Unknown | - | - | - | - |
| Ephemeroptera | | | | |
| Baetidae | - | - | - | - |
| Caenidae | 0.1 | Trace | - | - |
| Unknown | - | - | Trace | - |

Appendix G. Continued.

| Invertebrate Taxa | Wetland Basin Type | | | |
|---|---|---|---|---|
| | Pond | Semipermanent Marsh | Seasonal Marsh | Temporary Marsh |
| Hymenoptera | | | | |
| Pompilidae | - | - | - | - |
| Unknown | - | - | - | - |
| Odonata | | | | |
| Aeshnidae | - | - | - | - |
| Cordulegasteridae | - | Trace | - | - |
| Lestidae | 0.1 | 0.3 | Trace | 0.1 |
| Coenagrionidae | Trace | Trace | - | - |
| Hemiptera | | | | |
| Ciccadellidae | - | - | - | - |
| Hebridae | - | - | - | - |
| Mesoveliidae | - | - | - | - |
| Gerridae | - | - | - | - |
| Veliidae | Trace | - | - | - |
| Notonectidae | Trace | - | - | - |
| Pleidae | Trace | Trace | Trace | - |
| Nepidae | - | - | - | - |
| Belostomatidae | - | - | - | - |
| Corixidae | Trace | - | - | 0.1 |
| Unknown | Trace | - | - | - |
| Megaloptera | - | - | - | Trace |
| Trichoptera | | | | |
| Lepidostomatidae | - | - | - | - |
| Odontoceridae | - | Trace | - | - |
| Polycentropodidae | - | - | - | - |
| Unknown | Trace | - | - | - |

Appendix G. Continued.

| Invertebrate Taxa | Wetland Basin Type | | | |
|---|---|---|---|---|
| | Pond | Semipermanent Marsh | Seasonal Marsh | Temporary Marsh |
| Coleoptera | | | | |
| Haliplidae | Trace | Trace | Trace | - |
| Dytiscidae | 0.1 | 0.1 | 0.1 | 0.1 |
| Elmidae | - | - | - | - |
| Coccinellidae | - | - | - | - |
| Chrysomelidae | - | - | - | - |
| Curculionidae | - | - | - | - |
| Unknown | Trace | Trace | Trace | - |
| Diptera | | | | |
| Tipulidae | - | Trace | - | - |
| Psychodidae | - | Trace | - | - |
| Dixidae | - | - | - | - |
| Culicidae | 0.1 | 0.9 | 0.5 | 0.4 |
| Chaoboridae | 0.3 | 0.4 | Trace | 0.4 |
| Chironomidae | | | | |
| Tanypodinae | Trace | 0.2 | Trace | - |
| Other | 0.9 | 1.2 | 0.1 | 4.6 |
| Heleidae | Trace | Trace | Trace | - |
| Stratiomyidae | 0.1 | Trace | Trace | - |
| Tabananidae | Trace | 0.1 | - | - |
| Sciomyzidae | Trace | Trace | - | - |
| Ephydridae | - | - | - | - |
| Anthomyiidae | - | - | Trace | - |
| Unknown | Trace | Trace | Trace | - |

Appendix G. Continued.

| Invertebrate Taxa | Wetland Basin Type<br>Pond | <br>Semipermanent Marsh | <br>Seasonal Marsh | <br>Temporary Marsh |
|---|---|---|---|---|
| Mollusca | | | | |
| Gastropoda | | | | |
| Physidae | 0.1 | 0.1 | 0.1 | - |
| Lymnaeidae | 0.1 | 0.9 | 0.5 | 0.1 |
| Planorbidae | 0.1 | 0.6 | 0.2 | Trace |
| Unknown | - | - | - | - |
| Pelecypoda | | | | |
| Sphaeriidae | 0.2 | 1.1 | Trace | - |
| Unknown | - | Trace | - | - |
| Unknown | Trace | Trace | Trace | 0.1 |
| Total organisms | 32,694 | 19,631 | 37,236 | 3,411 |

Trace = less than 0.1 %

Appendix H. Percent composition (number of organisms) of aquatic invertebrate taxa by wetland basin type collected in nektonic samples from 25 - 26 May 1991 (sampling period IV) in northeastern Illinois.

| Invertebrate Taxa | Wetland Basin Type | | | |
|---|---|---|---|---|
| | Pond | Semipermanent Marsh | Seasonal Marsh | Temporary Marsh |
| Protozoa | | | | |
| Testacida | 13.2 | 0.7 | 0.2 | - |
| Unknown | - | - | - | - |
| Coelenterata | | | | |
| Hydridae | Trace | Trace | 0.2 | 0.2 |
| Turbellaria | | | | |
| Planaridae | - | Trace | - | - |
| Rotifera | - | 0.1 | - | - |
| Nematoda | - | - | - | 3.3 |
| Annelida | | | | |
| Oligochaeta | | | | |
| Aquatic | 5.3 | 3.2 | 0.1 | 3.5 |
| Terrestrial | - | - | - | - |
| Hirudinea | 0.3 | 0.1 | 0.1 | - |
| Arthropoda | | | | |
| Crustacea | | | | |
| Anostraca | | | | |
| Chirocephalidae | - | Trace | - | - |

Appendix H. Continued.

| Invertebrate Taxa | Wetland Basin Type | | | |
|---|---|---|---|---|
| | Pond | Semipermanent Marsh | Seasonal Marsh | Temporary Marsh |
| Conchostraca | 0.1 | 0.1 | 8.5 | - |
| Cladocera | 30.5 | 43.2 | 11.4 | 4.8 |
| Copepoda | 25.1 | 4.9 | 1.6 | 7.9 |
| Ostracoda | 0.3 | 31.8 | 63.8 | 0.4 |
| Chilopoda | - | - | - | - |
| Isopoda | | | | |
| Asellidae | 0.6 | 3.7 | 0.7 | 53.6 |
| Amphipoda | | | | |
| Talitridae | - | - | - | - |
| Gammaridae | 1.2 | 0.7 | 0.1 | 0.4 |
| Decapoda | | | | |
| Astacidae | - | - | - | - |
| Hydracarina | | | | |
| Hydracnidae | 0.5 | 0.2 | Trace | 1.1 |
| Insecta | | | | |
| Collembola | | | | |
| Isotomidae | Trace | 0.2 | 1.2 | 0.4 |
| Plecoptera | | | | |
| Nemouridae | - | - | - | - |
| Perlodidae | - | - | - | - |
| Unknown | - | Trace | - | - |
| Ephemeroptera | | | | |
| Baetidae | 0.1 | Trace | - | - |
| Caenidae | Trace | Trace | - | - |
| Unknown | Trace | - | - | - |

Appendix H. Continued.

| Invertebrate Taxa | Wetland Basin Type<br>Pond | <br>Semipermanent Marsh | <br>Seasonal Marsh | <br>Temporary Marsh |
|---|---|---|---|---|
| Hymenoptera | | | | |
| Pompilidae | - | - | - | - |
| Unknown | Trace | Trace | Trace | - |
| Odonata | | | | |
| Aeshnidae | Trace | - | - | - |
| Cordulegasteridae | - | - | - | - |
| Lestidae | 0.2 | 0.3 | 0.1 | 1.1 |
| Coenagrionidae | Trace | - | - | - |
| Hemiptera | | | | |
| Ciccadellidae | Trace | - | 0.1 | - |
| Hebridae | - | - | 0.1 | - |
| Mesoveliidae | Trace | Trace | Trace | - |
| Gerridae | - | Trace | - | - |
| Veliidae | Trace | 0.2 | Trace | - |
| Notonectidae | Trace | - | 0.1 | - |
| Pleidae | 0.1 | - | Trace | - |
| Nepidae | - | Trace | - | - |
| Belostomatidae | Trace | - | - | - |
| Corixidae | 0.3 | 0.1 | Trace | 0.4 |
| Unknown | Trace | - | Trace | 0.5 |
| Megaloptera | - | - | - | - |
| Trichoptera | | | | |
| Lepidostomatidae | - | - | Trace | - |
| Odontoceridae | 0.1 | 0.1 | Trace | 1.8 |
| Polycentropodidae | - | - | Trace | - |
| Unknown | Trace | Trace | - | - |

Appendix H. Continued.

| Invertebrate Taxa | Wetland Basin Type | | | |
|---|---|---|---|---|
| | Pond | Semipermanent Marsh | Seasonal Marsh | Temporary Marsh |
| Coleoptera | | | | |
| Haliplidae | 0.4 | Trace | Trace | 0.2 |
| Dytiscidae | 0.3 | 0.3 | 0.3 | 0.4 |
| Elmidae | - | - | - | - |
| Coccinellidae | - | - | - | - |
| Chrysomelidae | - | - | Trace | - |
| Curculionidae | 0.1 | Trace | Trace | - |
| Unknown | Trace | Trace | 0.1 | - |
| Diptera | | | | |
| Tipulidae | 0.1 | 0.1 | - | - |
| Psychodidae | - | Trace | Trace | 7.5 |
| Dixidae | - | Trace | Trace | - |
| Culicidae | 0.2 | 0.1 | Trace | 0.4 |
| Chaoboridae | 2.4 | 4.7 | 0.4 | 0.2 |
| Chironomidae | | | | |
| Tanypodinae | 0.4 | 0.3 | 0.1 | - |
| Other | 4.7 | 1.7 | 0.4 | 10.4 |
| Heleidae | Trace | Trace | - | - |
| Stratiomyidae | 0.1 | 0.1 | Trace | 0.2 |
| Tabananidae | - | - | - | - |
| Sciomyzidae | Trace | Trace | 0.1 | - |
| Ephydridae | - | - | 0.2 | - |
| Anthomyiidae | - | - | 0.3 | - |
| Unknown | 0.1 | Trace | 0.2 | 1.1 |

Appendix H. Continued.

| Invertebrate Taxa | Wetland Basin Type<br>Pond | <br>Semipermanent Marsh | <br>Seasonal Marsh | <br>Temporary Marsh |
|---|---|---|---|---|
| Mollusca | | | | |
| Gastropoda | | | | |
| Physidae | 3.6 | 0.1 | 1.0 | - |
| Lymnaeidae | 1.2 | 0.6 | 5.1 | 0.2 |
| Planorbidae | 3.9 | 0.9 | 3.2 | 0.2 |
| Unknown | - | - | - | - |
| Pelecypoda | | | | |
| Sphaeriidae | 4.2 | 1.1 | Trace | - |
| Unknown | - | - | - | - |
| Unknown | Trace | 0.1 | Trace | 0.2 |
| Total organisms | 16,144 | 22,934 | 13,448 | 547 |

Trace = less than 0.1 %

Appendix I. Numbers of other wetland bird species observed on temporary, seasonal, and semipermanent marshes, and ponds 23 March - 10 April 1990 in northeastern Illinois.

| | Wetland type | | | | |
|---|---|---|---|---|---|
| Species | Temporary Marsh (n=66) | Seasonal Marsh (n=77) | Semi-permanent Marsh (n=83) | Pond (n=66) | Total |
| Pied-billed grebe | 0 | 0 | 1 | 4 | 5 |
| Double-crested cormorant | 0 | 0 | 0 | 0 | 0 |
| American bittern | 0 | 0 | 0 | 0 | 0 |
| Least bittern | 0 | 0 | 0 | 0 | 0 |
| Great blue heron | 1 | 0 | 8 | 0 | 9 |
| Great egret | 0 | 0 | 1 | 0 | 1 |
| Green-backed heron | 0 | 0 | 0 | 0 | 0 |
| Black-crowned night heron | 0 | 0 | 2 | 0 | 2 |
| Sora | 0 | 0 | 0 | 0 | 0 |
| American coot | 0 | 0 | 331 | 0 | 331 |
| Sandhill crane | 1 | 0 | 4 | 0 | 5 |
| Greater yellowlegs | 0 | 0 | 0 | 0 | 0 |
| Lesser yellowlegs | 0 | 0 | 0 | 0 | 0 |
| Solitary sandpiper | 0 | 0 | 0 | 0 | 0 |
| Spotted sandpiper | 0 | 0 | 0 | 0 | 0 |
| Pectoral sandpiper | 0 | 0 | 0 | 0 | 0 |
| Unknown sandpiper | 0 | 0 | 0 | 0 | 0 |
| Dunlin | 0 | 0 | 0 | 0 | 0 |
| Common snipe | 6 | 76 | 92 | 2 | 176 |
| Common tern | 0 | 0 | 0 | 0 | 0 |
| Forster's tern | 0 | 0 | 0 | 0 | 0 |
| Black tern | 0 | 0 | 0 | 0 | 0 |
| Belted kingfisher | 2 | 2 | 3 | 1 | 8 |
| Marsh wren | 0 | 0 | 13 | 0 | 13 |
| Yellow-headed blackbird | 0 | 0 | 0 | 0 | 0 |
| Total birds | 10 | 78 | 455 | 7 | 550 |
| Total species | 4 | 2 | 9 | 3 | 9 |

Appendix J. Numbers of other wetland bird species observed on temporary, seasonal, and semipermanent marshes, and ponds 18 April - 8 May 1990 in northeastern Illinois.

| | Wetland type | | | | |
|---|---|---|---|---|---|
| Species | Temporary Marsh (n=66) | Seasonal Marsh (n=77) | Semi-permanent Marsh (n=83) | Pond (n=66) | Total |
| Pied-billed grebe | 0 | 0 | 6 | 2 | 8 |
| Double-crested cormorant | 0 | 0 | 1 | 0 | 1 |
| American bittern | 0 | 3 | 0 | 0 | 3 |
| Least bittern | 0 | 0 | 0 | 0 | 0 |
| Great blue heron | 2 | 1 | 15 | 0 | 18 |
| Great egret | 1 | 0 | 1 | 0 | 2 |
| Green-backed heron | 1 | 3 | 19 | 7 | 30 |
| Black-crowned night-heron | 0 | 0 | 1 | 0 | 1 |
| Sora | 0 | 10 | 54 | 0 | 64 |
| American coot | 0 | 1 | 249 | 2 | 252 |
| Sandhill crane | 0 | 0 | 3 | 6 | 9 |
| Greater yellowlegs | 0 | 5 | 20 | 0 | 25 |
| Lesser yellowlegs | 11 | 11 | 87 | 0 | 109 |
| Solitary sandpiper | 3 | 5 | 5 | 2 | 15 |
| Spotted sandpiper | 6 | 0 | 1 | 0 | 7 |
| Pectoral sandpiper | 0 | 9 | 52 | 6 | 67 |
| Unknown sandpiper | 0 | 0 | 4 | 0 | 4 |
| Dunlin | 0 | 0 | 0 | 0 | 0 |
| Common snipe | 14 | 112 | 605 | 2 | 733 |
| Common tern | 0 | 0 | 0 | 0 | 0 |
| Forster's tern | 0 | 0 | 0 | 0 | 0 |
| Black tern | 0 | 0 | 0 | 0 | 0 |
| Belted kingfisher | 2 | 3 | 2 | 1 | 8 |
| Marsh wren | 0 | 0 | 2 | 0 | 2 |
| Yellow-headed blackbird | 0 | 0 | 4 | 0 | 4 |
| Total birds | 40 | 163 | 1,131 | 28 | 1,362 |
| Total species | 8 | 11 | 19 | 8 | 20 |

Appendix K. Numbers of other wetland bird species observed on temporary, seasonal, and semipermanent marshes, and ponds 1-18 April 1991 in northeastern Illinois.

| | Wetland type | | | | |
|---|---|---|---|---|---|
| Species | Temporary Marsh (n=95) | Seasonal Marsh (n=85) | Semi-permanent Marsh (n=98) | Pond (n=102) | Total |
| Pied-billed grebe | 0 | 0 | 11 | 0 | 11 |
| Double-crested cormorant | 0 | 0 | 0 | 0 | 0 |
| American bittern | 0 | 1 | 1 | 0 | 2 |
| Least bittern | 0 | 0 | 0 | 0 | 0 |
| Great blue heron | 0 | 1 | 20 | 0 | 21 |
| Great egret | 0 | 0 | 1 | 0 | 1 |
| Green-backed heron | 0 | 0 | 0 | 0 | 0 |
| Black-crowned night-heron | 0 | 0 | 10 | 0 | 10 |
| Sora | 0 | 3 | 5 | 0 | 8 |
| American coot | 0 | 3 | 564 | 0 | 567 |
| Sandhill crane | 0 | 0 | 3 | 0 | 3 |
| Greater yellowlegs | 0 | 0 | 0 | 0 | 0 |
| Lesser yellowlegs | 8 | 0 | 14 | 0 | 22 |
| Solitary sandpiper | 0 | 0 | 0 | 0 | 0 |
| Spotted sandpiper | 0 | 0 | 0 | 0 | 0 |
| Pectoral sandpiper | 0 | 6 | 1 | 0 | 7 |
| Unknown sandpiper | 0 | 0 | 0 | 0 | 0 |
| Dunlin | 0 | 0 | 0 | 0 | 0 |
| Common snipe | 42 | 71 | 118 | 39 | 270 |
| Common tern | 0 | 0 | 0 | 0 | 0 |
| Forster's tern | 0 | 0 | 2 | 0 | 2 |
| Black tern | 0 | 0 | 0 | 0 | 0 |
| Belted kingfisher | 0 | 2 | 5 | 1 | 8 |
| Marsh wren | 0 | 0 | 0 | 0 | 0 |
| Yellow-headed blackbird | 0 | 0 | 1 | 0 | 1 |
| Total birds | 50 | 87 | 756 | 40 | 933 |
| Total species | 2 | 7 | 14 | 2 | 14 |

Appendix L. Numbers of other wetland bird species observed on temporary, seasonal, and semipermanent marshes, and ponds 27 April - 17 May 1991 in northeastern Illinois.

| | Wetland type | | | | |
|---|---|---|---|---|---|
| Species | Temporary Marsh (n=95) | Seasonal Marsh (n=85) | Semipermanent Marsh (n=98) | Pond (n=102) | Total |
| Pied-billed grebe | 0 | 2 | 7 | 0 | 9 |
| Double-crested cormorant | 0 | 0 | 1 | 0 | 1 |
| American bittern | 0 | 1 | 0 | 0 | 1 |
| Least bittern | 0 | 0 | 0 | 0 | 0 |
| Great blue heron | 0 | 1 | 45 | 3 | 49 |
| Great egret | 0 | 0 | 2 | 1 | 3 |
| Green-backed heron | 0 | 4 | 19 | 3 | 26 |
| Black-crowned night-heron | 0 | 0 | 9 | 0 | 9 |
| Sora | 3 | 38 | 95 | 0 | 136 |
| American coot | 0 | 0 | 56 | 0 | 56 |
| Sandhill crane | 0 | 0 | 3 | 0 | 3 |
| Greater yellowlegs | 0 | 0 | 22 | 0 | 22 |
| Lesser yellowlegs | 9 | 24 | 11 | 2 | 46 |
| Solitary sandpiper | 0 | 1 | 0 | 0 | 1 |
| Spotted sandpiper | 3 | 1 | 6 | 0 | 10 |
| Pectoral sandpiper | 9 | 2 | 7 | 2 | 20 |
| Unknown sandpiper | 0 | 0 | 50 | 0 | 50 |
| Dunlin | 0 | 0 | 0 | 0 | 0 |
| Common snipe | 0 | 13 | 9 | 11 | 33 |
| Common tern | 0 | 0 | 1 | 0 | 1 |
| Forster's tern | 0 | 0 | 16 | 0 | 16 |
| Black tern | 0 | 0 | 14 | 0 | 14 |
| Belted kingfisher | 0 | 0 | 2 | 0 | 2 |
| Marsh wren | 0 | 0 | 0 | 0 | 0 |
| Yellow-headed blackbird | 0 | 2 | 17 | 0 | 19 |
| Total birds | 24 | 89 | 392 | 22 | 527 |
| Total species | 4 | 11 | 20 | 6 | 22 |

Appendix M. Numbers of other wetland bird species observed on temporary, seasonal, and semipermanent marshes, and ponds 25 May - 12 June 1991 in northeastern Illinois.

| | Wetland type | | | | |
|---|---|---|---|---|---|
| Species | Temporary Marsh (n=95) | Seasonal Marsh (n=85) | Semi-permanent Marsh (n=98) | Pond (n=102) | Total |
| Pied-billed grebe | 0 | 0 | 7 | 0 | 7 |
| Double-crested cormorant | 0 | 0 | 0 | 0 | 0 |
| American bittern | 0 | 5 | 0 | 0 | 5 |
| Least bittern | 0 | 1 | 3 | 0 | 4 |
| Great blue heron | 2 | 5 | 62 | 1 | 70 |
| Great egret | 6 | 0 | 6 | 0 | 12 |
| Green-backed heron | 3 | 16 | 26 | 4 | 49 |
| Black-crowned night heron | 0 | 0 | 1 | 0 | 1 |
| Sora | 2 | 22 | 13 | 0 | 37 |
| American coot | 0 | 0 | 42 | 0 | 42 |
| Sandhill crane | 0 | 1 | 2 | 0 | 3 |
| Greater yellowleg | 0 | 0 | 0 | 0 | 0 |
| Lesser yellowlegs | 0 | 0 | 0 | 0 | 0 |
| Solitary sandpiper | 0 | 0 | 0 | 0 | 0 |
| Spotted sandpiper | 0 | 0 | 0 | 0 | 0 |
| Pectoral sandpiper | 0 | 0 | 0 | 0 | 0 |
| Unknown sandpiper | 0 | 0 | 0 | 0 | 0 |
| Dunlin | 0 | 0 | 0 | 0 | 0 |
| Common snipe | 50 | 1 | 2 | 0 | 53 |
| Common tern | 0 | 0 | 3 | 0 | 3 |
| Forster's tern | 0 | 0 | 20 | 0 | 20 |
| Black tern | 0 | 0 | 24 | 0 | 24 |
| Belted kingfisher | 0 | 1 | 2 | 0 | 3 |
| Marsh wren | 0 | 0 | 23 | 0 | 23 |
| Yellow-headed blackbird | 0 | 6 | 18 | 0 | 24 |
| Total birds | 63 | 58 | 254 | 5 | 380 |
| Total species | 5 | 9 | 16 | 2 | 17 |

Appendix N. Common and scientific names of other wetland bird species observed in northeastern Illinois wetlands during springs 1990-91.

| Common name | Scientific name |
|---|---|
| pied-billed grebe | *Podilymbus podiceps* |
| double-crested cormorant | *Phalacrocorax auritus* |
| American bittern | *Botaurus lentiginosus* |
| least bittern | *Ixobrychus exilis* |
| great blue heron | *Ardea herodias* |
| great egret | *Casmerodius albus* |
| green-backed heron | *Butorides striatus* |
| black-crowned night-heron | *Nycticorax nycticorax* |
| sora | *Porzana carolina* |
| American coot | *Fulica americana* |
| sandhill crane | *Grus canadensis* |
| greater yellowlegs | *Tringa melanoleuca* |
| lesser yellowlegs | *T. flavipes* |
| solitary sandpiper | *T. solitaria* |
| spotted sandpiper | *Actitis macularia* |
| pectoral sandpiper | *Calidris melanotos* |
| dunlin | *C. alpina* |
| common snipe | *Gallinago gallinago* |
| common tern | *Sterna hirundo* |
| Forster's tern | *S. forsteri* |
| black tern | *Chlidonias niger* |
| belted kingfisher | *Ceryle alcyon* |
| marsh wren | *Cistothorus palustris* |
| yellow-headed blackbird | *Xanthocephalus xanthocephalus* |

Appendix O. Numbers of waterfowl observed as pairs, males and females in mixed and single sex flocks, unknown sex, and total birds by species on semipermanent, seasonal, temporary marshes, and ponds during wetland surveys conducted 23 March - 10 April 1990 in northeastern Illinois.

| Wetland type (n) | | Mixed sex flocks | | Single sex flocks | | Unknown | Total |
|---|---|---|---|---|---|---|---|
| Species | Pairs | Males | Females | Males | Females | sex | birds |
| Semipermanent marsh (83) | | | | | | | |
| American wigeon | 2 | 9 | 7 | 0 | 0 | 20 | 40 |
| Black duck | 6 | 0 | 0 | 1 | 0 | 0 | 13 |
| Bufflehead | 2 | 1 | 2 | 0 | 0 | 0 | 7 |
| Blue-winged teal | 16 | 30 | 15 | 9 | 0 | 44 | 130 |
| Canada goose | 118 | 0 | 0 | 0 | 2 | 443 | 681 |
| Common goldeneye | 2 | 0 | 0 | 1 | 0 | 0 | 5 |
| Green-winged teal | 4 | 1 | 0 | 2 | 1 | 33 | 45 |
| Hooded merganser | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| Lesser scaup | 0 | 12 | 10 | 1 | 0 | 5 | 28 |
| Mallard | 191 | 13 | 8 | 19 | 4 | 0 | 426 |
| Northern shoveler | 23 | 19 | 8 | 8 | 0 | 0 | 81 |
| Redhead | 0 | 0 | 0 | 2 | 0 | 0 | 2 |
| Ring-necked duck | 12 | 22 | 12 | 0 | 0 | 51 | 109 |

Appendix O. Continued.

| Wetland type (n)<br>Species | Pairs | Mixed sex flocks<br>Males | | Mixed sex flocks<br>Females | Single sex flocks<br>Males | Single sex flocks<br>Females | | Unknown sex | Total birds |
|---|---|---|---|---|---|---|---|---|---|
| Semipermanent marsh cont. | | | | | | | | | |
| Ruddy duck | 0 | 3 | | 2 | 2 | 0 | | 0 | 7 |
| Unknown teal | 0 | 0 | | 0 | 0 | 0 | | 118 | 118 |
| Wood duck | 45 | 4 | | 2 | 7 | 0 | | 0 | 103 |
| Seasonal Marsh (77) | | | | | | | | | |
| American wigeon | 3 | 1 | 0 | 0 | 0 | 1 | 0 | 6 | 13 |
| Black duck | 0 | 7 | 2 | 4 | 2 | 3 | 0 | 0 | 9 |
| Canada goose | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 55 | 107 |
| Green-winged teal | 15 | 5 | 2 | 4 | 2 | 1 | 0 | 22 | 59 |
| Hooded merganser | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| Mallard | 124 | 14 | 3 | 1 | 2 | 13 | 1 | 0 | 265 |
| Northern pintail | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Northern shoveler | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 35 |
| Ring-necked duck | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 |
| Wood duck | 17 | 4 | 0 | 0 | 0 | 4 | 0 | 0 | 38 |

Appendix O. Continued.

| Wetland type (n)<br>Species | Pairs | Mixed sex flocks<br>Males | <br>Females | Single sex flocks<br>Males | <br>Females | Unknown sex | Total birds |
|---|---|---|---|---|---|---|---|
| Temporary marsh (66) | | | | | | | |
| Black duck | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| Blue-winged teal | 1 | 2 | 1 | 0 | 0 | 0 | 5 |
| Canada goose | 10 | 0 | 0 | 0 | 0 | 557 | 577 |
| Lesser scaup | 2 | 0 | 0 | 0 | 0 | 0 | 4 |
| Mallard | 25 | 11 | 5 | 8 | 0 | 0 | 74 |
| Northern shoveler | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| Wood duck | 6 | 0 | 0 | 0 | 0 | 0 | 12 |
| Pond (66) | | | | | | | |
| Bufflehead | 0 | 4 | 2 | 3 | 0 | 0 | 9 |
| Canada goose | 26 | 0 | 0 | 0 | 0 | 254 | 306 |
| Lesser scaup | 1 | 83 | 54 | 4 | 0 | 0 | 143 |
| Mallard | 37 | 20 | 11 | 22 | 0 | 0 | 127 |
| Ring-necked duck | 2 | 5 | 1 | 0 | 0 | 0 | 10 |
| Wood duck | 15 | 0 | 0 | 0 | 0 | 0 | 30 |

Appendix P. Numbers of waterfowl observed as pairs, males and females in mixed and single single sex flocks, unknown sex, and total birds by species on semipermanent, seasonal, temporary marshes, and ponds during wetland surveys conducted 18 April - 8 May 1990 in northeastern Illinois.

| Wetland type (n)<br>Species | Pairs | Mixed sex flocks<br>Males | Mixed sex flocks<br>Females | Single sex flocks<br>Males | Single sex flocks<br>Females | Unknown sex | Total birds |
|---|---|---|---|---|---|---|---|
| Semipermanent marsh (83) | | | | | | | |
| American wigeon | 7 | 2 | 1 | 0 | 0 | 0 | 17 |
| Black duck | 2 | 0 | 0 | 1 | 0 | 0 | 5 |
| Blue-winged teal | 86 | 11 | 5 | 15 | 1 | 105 | 309 |
| Canada goose | 132 | 0 | 0 | 0 | 2 | 199 | 465 |
| Gadwall | 2 | 0 | 0 | 0 | 0 | 23 | 27 |
| Green-winged teal | 14 | 3 | 1 | 2 | 0 | 45 | 79 |
| Lesser scaup | 0 | 6 | 5 | 1 | 0 | 0 | 12 |
| Mallard | 101 | 17 | 8 | 107 | 8 | 0 | 347 |
| Northern shoveler | 19 | 7 | 3 | 12 | 0 | 0 | 60 |
| Red-breasted merganser | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Ring-necked duck | 3 | 0 | 0 | 23 | 16 | 32 | 77 |
| Unknown teal | 0 | 0 | 0 | 0 | 0 | 5 | 5 |
| Wood duck | 25 | 0 | 0 | 30 | 1 | 0 | 81 |

Appendix P. Continued.

| Wetland type (n)<br>Species | Pairs | Mixed sex flocks<br>Males | <br>Females | Single sex flocks<br>Males | <br>Females | Unknown sex | Total birds |
|---|---|---|---|---|---|---|---|
| Seasonal Marsh (77) | | | | | | | |
| Blue-winged teal | 15 | 0 | 0 | 1 | 0 | 0 | 31 |
| Canada goose | 26 | 0 | 0 | 0 | 1 | 34 | 87 |
| Mallard | 20 | 0 | 0 | 41 | 4 | 0 | 85 |
| Northern shoveler | 1 | 0 | 0 | 1 | 0 | 0 | 3 |
| Wood duck | 15 | 2 | 1 | 9 | 4 | 0 | 46 |
| Temporary marsh (66) | | | | | | | |
| Blue-winged teal | 7 | 4 | 1 | 2 | 0 | 0 | 21 |
| Canada goose | 8 | 0 | 0 | 0 | 0 | 3 | 19 |
| Mallard | 10 | 0 | 0 | 16 | 0 | 0 | 41 |
| Ring-necked duck | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Wood duck | 6 | 0 | 0 | 4 | 0 | 0 | 16 |
| Pond (66) | | | | | | | |
| Bufflehead | 0 | 1 | 5 | 0 | 0 | 0 | 6 |
| Blue-winged teal | 4 | 0 | 0 | 0 | 0 | 0 | 8 |

Appendix P. Continued.

| Wetland type (n)<br>Species | Pairs | Mixed sex flocks<br>Males | <br>Females | Single sex flocks<br>Males | <br>Females | Unknown sex | Total birds |
|---|---|---|---|---|---|---|---|
| Pond cont. | | | | | | | |
| Canada goose | 17 | 0 | 0 | 0 | 0 | 19 | 53 |
| Lesser scaup | 5 | 0 | 0 | 4 | 0 | 0 | 14 |
| Mallard | 12 | 15 | 3 | 59 | 5 | 0 | 129 |
| Ring-necked duck | 1 | 12 | 7 | 0 | 0 | 0 | 21 |
| Wood duck | 7 | 0 | 0 | 2 | 0 | 0 | 16 |

Appendix Q. Numbers of waterfowl observed as pairs, males and females in mixed and single sex flocks, unknown sex, and total birds by species on semipermanent, seasonal, temporary marshes, ponds, and streams during wetland surveys conducted 1-18 April 1991 in northeastern Illinois.

| Wetland type (n) | | Mixed sex flocks | | Single sex flocks | | | |
|---|---|---|---|---|---|---|---|
| Species | Pairs | Males | Females | Males | Females | Unknown sex | Total birds |
| Semipermanent marsh (98) | | | | | | | |
| American wigeon | 3 | 0 | 0 | 2 | 0 | 16 | 24 |
| Black duck | 6 | 0 | 0 | 2 | 0 | 2 | 16 |
| Bufflehead | 8 | 7 | 6 | 2 | 0 | 6 | 37 |
| Blue-winged teal | 73 | 36 | 13 | 14 | 1 | 216 | 426 |
| Canada goose | 197 | 0 | 0 | 0 | 4 | 542 | 940 |
| Common merganser | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| Gadwall | 7 | 0 | 0 | 0 | 0 | 2 | 16 |
| Green-winged teal | 20 | 2 | 1 | 1 | 0 | 50 | 94 |
| Lesser scaup | 0 | 0 | 0 | 1 | 0 | 100 | 101 |
| Mallard | 157 | 23 | 10 | 85 | 11 | 195 | 648 |
| Northern shoveler | 44 | 5 | 1 | 17 | 0 | 16 | 127 |
| Red-breasted merganser | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| Ring-necked duck | 24 | 1 | 2 | 8 | 0 | 552 | 611 |

Appendix Q. Continued.

| Wetland type (n)<br>Species | Pairs | Mixed sex flocks | | Single sex flocks | | Unknown sex | Total birds |
|---|---|---|---|---|---|---|---|
| | | Males | Females | Males | Females | | |
| Semipermanent marsh cont. | | | | | | | |
| Unknown teal | 0 | 0 | 0 | 0 | 0 | 15 | 15 |
| Wood duck | 35 | 4 | 2 | 5 | 1 | 0 | 82 |
| Seasonal Marsh (85) | | | | | | | |
| American green-winged teal | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| American wigeon | 0 | 0 | 0 | 3 | 0 | 0 | 3 |
| Black duck | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| Bufflehead | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| Blue-winged teal | 22 | 9 | 3 | 4 | 0 | 36 | 96 |
| Canada goose | 36 | 0 | 0 | 0 | 1 | 25 | 98 |
| Gadwall | 4 | 0 | 0 | 0 | 0 | 0 | 8 |
| Mallard | 54 | 2 | 1 | 32 | 5 | 0 | 148 |
| Northern shoveler | 9 | 11 | 4 | 0 | 0 | 16 | 49 |
| Ring-necked duck | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| Wood duck | 24 | 0 | 0 | 3 | 2 | 0 | 53 |

Appendix Q. Continued.

| Wetland type (n)<br>Species | Pairs | Mixed sex flocks<br>Males | <br>Females | Single sex flocks<br>Males | <br>Females | Unknown sex | Total birds |
|---|---|---|---|---|---|---|---|
| Temporary marsh (95) | | | | | | | |
| American green-winged teal | 2 | 5 | 1 | 0 | 0 | 36 | 46 |
| American wigeon | 0 | 0 | 0 | 0 | 0 | 50 | 50 |
| Bufflehead | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| Blue-winged teal | 7 | 2 | 1 | 3 | 0 | 14 | 34 |
| Canada goose | 6 | 0 | 0 | 0 | 0 | 284 | 296 |
| Hooded merganser | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| Lesser scaup | 0 | 5 | 1 | 0 | 0 | 0 | 6 |
| Mallard | 32 | 2 | 1 | 15 | 1 | 250 | 333 |
| Northern shoveler | 3 | 0 | 0 | 2 | 0 | 20 | 28 |
| Ring-necked duck | 2 | 0 | 0 | 0 | 0 | 0 | 4 |
| Unknown teal | 0 | 0 | 0 | 0 | 0 | 20 | 20 |
| Wood duck | 5 | 0 | 0 | 0 | 0 | 8 | 18 |
| Pond (102) | | | | | | | |
| Black duck | 0 | 0 | 0 | 1 | 0 | 0 | 1 |

Appendix Q. Continued.

| Wetland type (n)<br>Species | Pairs | Mixed sex flocks<br>Males | <br>Females | Single sex flocks<br>Males | <br>Females | Unknown sex | Total birds |
|---|---|---|---|---|---|---|---|
| Pond cont. | | | | | | | |
| Blue-winged teal | 3 | 0 | 0 | 0 | 0 | 0 | 6 |
| Bufflehead | 2 | 5 | 4 | 1 | 0 | 0 | 14 |
| Canada goose | 29 | 0 | 0 | 0 | 1 | 126 | 185 |
| Common goldeneye | 0 | 2 | 4 | 0 | 0 | 0 | 6 |
| Hooded merganser | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Lesser scaup | 2 | 15 | 4 | 1 | 0 | 0 | 24 |
| Mallard | 31 | 6 | 3 | 46 | 6 | 0 | 123 |
| Ring-necked duck | 1 | 23 | 6 | 6 | 0 | 0 | 37 |
| Wood duck | 8 | 6 | 2 | 2 | 0 | 0 | 26 |
| Stream (28) | | | | | | | |
| American green-winged teal | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| Blue-winged teal | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| Canada goose | 7 | 0 | 0 | 0 | 0 | 10 | 24 |

Appendix Q. Continued.

| Wetland type (n)<br>Species | Pairs | Mixed sex flocks<br>Males | Mixed sex flocks<br>Females | Single sex flocks<br>Males | Single sex flocks<br>Females | Unknown sex | Total birds |
|---|---|---|---|---|---|---|---|
| Stream cont. | | | | | | | |
| Hooded merganser | 3 | 0 | 0 | 0 | 0 | 0 | 6 |
| Mallard | 28 | 2 | 1 | 14 | 4 | 0 | 83 |
| Ring-necked duck | 5 | 0 | 0 | 0 | 0 | 11 | 21 |
| Wood duck | 25 | 0 | 0 | 0 | 1 | 0 | 51 |

Appendix R. Numbers of waterfowl observed as pairs, males and females in mixed and single sex flocks, unknown sex, and total birds by species on semipermanent, seasonal, temporary marshes, ponds, and streams during wetland surveys conducted 27 April - 17 May 1991 in northeastern Illinois.

| Wetland type (n) | | Mixed sex flocks | | Single sex flocks | | | |
|---|---|---|---|---|---|---|---|
| Species | Pairs | Males | Females | Males | Females | Unknown sex | Total birds |
| Semipermanent marsh (98) | | | | | | | |
| American wigeon | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Bufflehead | 2 | 0 | 0 | 0 | 0 | 0 | 4 |
| Blue-winged teal | 36 | 10 | 4 | 27 | 4 | 7 | 124 |
| Canada goose | 200 | 0 | 0 | 0 | 6 | 217 | 623 |
| Hooded merganser | 0 | 0 | 0 | 0 | 2 | 0 | 2 |
| Mallard | 51 | 6 | 3 | 131 | 14 | 0 | 261 |
| Northern shoveler | 2 | 0 | 0 | 4 | 0 | 0 | 8 |
| Redhead | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Ring-necked duck | 9 | 0 | 0 | 0 | 0 | 0 | 18 |
| Ruddy duck | 3 | 0 | 0 | 1 | 0 | 0 | 12 |
| Wood duck | 13 | 2 | 1 | 47 | 2 | 3 | 81 |

Appendix R. Continued.

| Wetland type (n)<br>Species | Pairs | Mixed sex flocks |  | Single sex flocks |  | Unknown sex | Total birds |
|---|---|---|---|---|---|---|---|
|  |  | Males | Females | Males | Females |  |  |
| Seasonal Marsh (85) |  |  |  |  |  |  |  |
| Blue-winged teal | 12 | 0 | 0 | 17 | 1 | 0 | 42 |
| Canada goose | 38 | 0 | 0 | 0 | 1 | 30 | 107 |
| Mallard | 24 | 0 | 0 | 33 | 7 | 4 | 92 |
| Northern shoveler | 1 | 0 | 0 | 1 | 0 | 0 | 3 |
| Wood duck | 10 | 0 | 0 | 4 | 2 | 0 | 26 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Temporary marsh (95) |  |  |  |  |  |  |  |
| Blue-winged teal | 6 | 2 | 1 | 3 | 0 | 0 | 18 |
| Canada goose | 11 | 0 | 0 | 0 | 0 | 20 | 42 |
| Mallard | 6 | 0 | 0 | 24 | 0 | 0 | 36 |
| Northern pintail | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Wood duck | 3 | 0 | 0 | 3 | 0 | 0 | 9 |
| Pond (102) |  |  |  |  |  |  |  |
| Bufflehead | 0 | 1 | 3 | 0 | 0 | 0 | 4 |

Appendix R. Continued.

| Wetland type (n)<br>Species | Pairs | Mixed sex flocks<br>Males | Mixed sex flocks<br>Females | Single sex flocks<br>Males | Single sex flocks<br>Females | Unknown sex | Total birds |
|---|---|---|---|---|---|---|---|
| Pond cont. | | | | | | | |
| Blue-winged teal | 2 | 0 | 0 | 2 | 0 | 0 | 6 |
| Canada goose | 36 | 0 | 0 | 0 | 9 | 39 | 111 |
| Mallard | 10 | 6 | 1 | 65 | 2 | 0 | 107 |
| Northern shoveler | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| Wood duck | 4 | 2 | 1 | 6 | 0 | 0 | 17 |
| Stream (28) | | | | | | | |
| Canada goose | 4 | 0 | 0 | 2 | 0 | 10 | 20 |
| Mallard | 12 | 0 | 0 | 27 | 3 | 0 | 59 |
| Wood duck | 8 | 2 | 2 | 10 | 1 | 0 | 30 |

Appendix S. Numbers of waterfowl observed as pairs, males and females in mixed and single sex flocks, unknown sex, and total birds by species on semipermanent, seasonal, temporary marshes, ponds, and streams during wetland surveys conducted 25 May - 12 June 1991 in northeastern Illinois.

| Wetland type (n)<br>Species | Pairs | Mixed sex flocks<br>Males | <br>Females | Single sex flocks<br>Males | <br>Females | Unknown sex | Total birds |
|---|---|---|---|---|---|---|---|
| Semipermanent marsh (98) | | | | | | | |
| American green-winged teal | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| Blue-winged teal | 15 | 0 | 0 | 18 | 1 | 4 | 53 |
| Canada goose | 68 | 0 | 0 | 0 | 1 | 123 | 260 |
| Mallard | 28 | 17 | 8 | 73 | 33 | 0 | 209 |
| Northern shoveler | 0 | 0 | 0 | 1 | 1 | 0 | 2 |
| Wood duck | 10 | 5 | 2 | 60 | 27 | 40 | 169 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 5 | 5 |
| Seasonal Marsh (85) | | | | | | | |
| Blue-winged teal | 3 | 0 | 0 | 8 | 1 | 0 | 15 |
| Canada goose | 3 | 0 | 0 | 0 | 0 | 58 | 64 |
| Mallard | 9 | 0 | 0 | 51 | 4 | 0 | 78 |
| Wood duck | 1 | 0 | 0 | 20 | 7 | 0 | 29 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Appendix S. Continued.

| Wetland type (n)<br>Species | Pairs | Mixed sex flocks |  | Single sex flocks |  | Unknown sex | Total birds |
|---|---|---|---|---|---|---|---|
|  |  | Males | Females | Males | Females |  |  |
| Temporary marsh (95) |  |  |  |  |  |  |  |
| American green-winged teal | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| Blue-winged teal | 1 | 0 | 0 | 6 | 0 | 0 | 8 |
| Canada goose | 9 | 0 | 0 | 0 | 0 | 80 | 98 |
| Mallard | 13 | 12 | 4 | 35 | 3 | 0 | 80 |
| Wood duck | 0 | 0 | 0 | 2 | 0 | 0 | 2 |
| Pond (102) |  |  |  |  |  |  |  |
| American green-winged teal | 1 | 0 | 0 | 1 | 0 | 0 | 3 |
| Blue-winged teal | 0 | 0 | 0 | 4 | 0 | 0 | 4 |
| Canada goose | 24 | 0 | 0 | 0 | 0 | 82 | 130 |
| Hooded merganser | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Mallard | 23 | 35 | 6 | 71 | 14 | 70 | 302 |
| Wood duck | 1 | 0 | 0 | 7 | 0 | 0 | 9 |

Appendix S. Continued.

| Wetland type (n) |  | Mixed sex flocks |  | Single sex flocks |  |  |  |
|---|---|---|---|---|---|---|---|
| Species | Pairs | Males | Females | Males | Females | Unknown sex | Total birds |
| Stream (28) |  |  |  |  |  |  |  |
| Blue-winged teal | 1 | 0 | 0 | 1 | 0 | 0 | 3 |
| Mallard | 8 | 0 | 0 | 11 | 3 | 0 | 37 |
| Wood duck | 1 | 0 | 0 | 0 | 0 | 0 | 2 |

Appendix T. Numbers of waterfowl observed as pairs, males and females in mixed and single sex flocks, unknown sex, and total birds by species on lakes, river segments, and semipermanent marshes surveyed by boat from 23 March - 10 April 1990 in northeastern Illinois.

| Wetland type (n) | | Mixed sex flocks | | Single sex flocks | | Unknown | Total |
|---|---|---|---|---|---|---|---|
| Species | Pairs | Males | Females | Males | Females | sex | birds |
| Lakes (13) | | | | | | | |
| American wigeon | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| Bufflehead | 4 | 0 | 0 | 2 | 0 | 0 | 10 |
| Blue-winged teal | 1 | 10 | 6 | 2 | 0 | 0 | 20 |
| Canada goose | 63 | 0 | 0 | 0 | 0 | 272 | 398 |
| Canvasback | 0 | 0 | 0 | 0 | 0 | 22 | 22 |
| Common goldeneye | 1 | 0 | 0 | 1 | 0 | 0 | 3 |
| Lesser scaup | 3 | 0 | 0 | 0 | 0 | 207 | 213 |
| Mallard | 47 | 9 | 3 | 28 | 1 | 0 | 135 |
| Mallard hybrid | 1 | 0 | 0 | 0 | 0 | 4 | 6 |
| Red-breasted merganser | 3 | 21 | 10 | 0 | 0 | 0 | 37 |
| Ring-necked duck | 0 | 21 | 24 | 0 | 0 | 452 | 497 |
| Wood duck | 7 | 0 | 0 | 2 | 0 | 0 | 16 |

Appendix T. Continued.

| Wetland type (n)<br>Species | Pairs | Mixed sex flocks<br>Males | Mixed sex flocks<br>Females | Single sex flocks<br>Males | Single sex flocks<br>Females | Unknown sex | Total birds |
|---|---|---|---|---|---|---|---|
| River segments (2) | | | | | | | |
| Canada goose | 16 | 0 | 0 | 0 | 0 | 57 | 89 |
| Mallard | 42 | 75 | 15 | 71 | 5 | 0 | 316 |
| Mallard hybrid | 0 | 0 | 0 | 22 | 0 | 0 | 22 |
| Wood duck | 2 | 0 | 0 | 2 | 0 | 0 | 6 |
| Semipermanent marsh (2) | | | | | | | |
| American green-winged teal | 2 | 0 | 0 | 0 | 0 | 27 | 31 |
| Bufflehead | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Blue-winged teal | 1 | 0 | 0 | 0 | 0 | 70 | 72 |
| Canada goose | 25 | 0 | 0 | 0 | 0 | 81 | 131 |
| Canvasback | 0 | 0 | 0 | 0 | 0 | 100 | 100 |
| Common merganser | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Lesser scaup | 0 | 0 | 0 | 0 | 0 | 13 | 13 |
| Mallard | 10 | 0 | 0 | 2 | 0 | 7 | 29 |
| Northern shoveler | 1 | 0 | 0 | 3 | 0 | 0 | 5 |

Appendix T. Continued.

| Wetland type (n)<br>Species | Pairs | Mixed sex flocks<br>Males | <br>Females | Single sex flocks<br>Males | <br>Females | Unknown sex | Total birds |
|---|---|---|---|---|---|---|---|
| Semipermanent marsh cont. | | | | | | | |
| Red-breasted merganser | 0 | 7 | 6 | 0 | 0 | 3 | 16 |
| Wood duck | 3 | 0 | 0 | 0 | 0 | 0 | 6 |

Appendix U. Numbers of waterfowl observed as pairs, males and females in mixed and single sex flocks, unknown sex, and total birds by species on lakes, river segments, and semipermanent marshes surveyed by boat from 18 April - 8 May 1990 in northeastern Illinois.

| Wetland type (n) | | Mixed sex flocks | | Single sex flocks | | Unknown sex | Total birds |
|---|---|---|---|---|---|---|---|
| Species | Pairs | Males | Females | Males | Females | | |
| Lakes (13) | | | | | | | |
| Blue-winged teal | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| Canada goose | 101 | 0 | 0 | 0 | 2 | 97 | 301 |
| Mallard | 22 | 13 | 6 | 64 | 3 | 6 | 147 |
| Mallard hybrid | 0 | 0 | 0 | 9 | 0 | 0 | 14 |
| Wood duck | 5 | 0 | 0 | 1 | 0 | 0 | 11 |
| River segments (2) | | | | | | | |
| Canada goose | 31 | 0 | 0 | 0 | 1 | 38 | 105 |
| Mallard | 19 | 25 | 10 | 150 | 2 | 0 | 237 |
| Mallard hybrid | 1 | 0 | 0 | 36 | 0 | 0 | 84 |
| Wood duck | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Semipermanent marsh (2) | | | | | | | |
| Blue-winged teal | 6 | 0 | 0 | 1 | 0 | 1 | 14 |

Appendix U. Continued.

| Wetland type (n)<br>Species | Pairs | Mixed sex flocks<br>Males | Mixed sex flocks<br>Females | Single sex flocks<br>Males | Single sex flocks<br>Females | Unknown sex | Total birds |
|---|---|---|---|---|---|---|---|
| Semipermanent marsh cont. | | | | | | | |
| Canada goose | 14 | 0 | 0 | 0 | 1 | 8 | 37 |
| Common merganser | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| Mallard | 6 | 0 | 0 | 19 | 1 | 6 | 38 |
| Wood duck | 1 | 0 | 0 | 6 | 0 | 0 | 8 |
| Unknown | 0 | 0 | 0 | 0 | 0 | 2 | 2 |

Appendix V. Numbers of waterfowl observed as pairs, males and females in mixed and single sex flocks, unknown sex, and total birds by species on lakes, river segments and semipermanent marshes surveyed by boat from 1-18 April 1991 in northeastern Illinois.

| Wetland type (n) | | Mixed sex flocks | | Single sex flocks | | Unknown | Total |
|---|---|---|---|---|---|---|---|
| Species | Pairs | Males | Females | Males | Females | sex | birds |
| Lakes (13) | | | | | | | |
| Bufflehead | 1 | 2 | 1 | 0 | 1 | 0 | 6 |
| Blue-winged teal | 0 | 0 | 0 | 4 | 0 | 0 | 4 |
| Canada goose | 78 | 0 | 0 | 1 | 3 | 437 | 597 |
| Hooded merganser | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Lesser scaup | 3 | 0 | 0 | 1 | 0 | 9 | 16 |
| Mallard | 23 | 28 | 8 | 40 | 5 | 0 | 127 |
| Mallard hybrid | 0 | 0 | 0 | 3 | 0 | 8 | 16 |
| Red-breasted merganser | 3 | 4 | 7 | 6 | 1 | 13 | 37 |
| Ring-necked duck | 7 | 2 | 1 | 1 | 0 | 0 | 18 |
| Ruddy duck | 0 | 0 | 0 | 4 | 0 | 0 | 4 |
| Wood duck | 2 | 0 | 0 | 1 | 0 | 0 | 5 |

Appendix V. Continued.

| Wetland type (n)<br>Species | Pairs | Mixed sex flocks<br>Males | <br>Females | Single sex flocks<br>Males | <br>Females | Unknown sex | Total birds |
|---|---|---|---|---|---|---|---|
| River segments (2) | | | | | | | |
| Blue-winged teal | 0 | 3 | 2 | 1 | 0 | 0 | 6 |
| Canada goose | 17 | 0 | 0 | 1 | 2 | 46 | 83 |
| Mallard | 19 | 23 | 7 | 111 | 3 | 4 | 201 |
| Mallard hybrid | 1 | 58 | 14 | 22 | 0 | 0 | 108 |
| Wood duck | 0 | 0 | 0 | 5 | 0 | 0 | 5 |
| Semipermanent marsh (2) | | | | | | | |
| Bufflehead | 0 | 2 | 1 | 0 | 0 | 0 | 3 |
| Blue-winged teal | 9 | 4 | 2 | 1 | 0 | 24 | 49 |
| Canada goose | 10 | 0 | 0 | 0 | 1 | 7 | 28 |
| Mallard | 6 | 2 | 1 | 12 | 0 | 0 | 27 |
| Red-breasted merganser | 3 | 0 | 0 | 0 | 0 | 0 | 6 |
| Wood duck | 3 | 0 | 0 | 2 | 0 | 0 | 8 |

Appendix W. Numbers of waterfowl observed as pairs, males and females in mixed and single sex flocks, unknown sex, and total birds by species on lakes, river segments, and semipermanent marshes surveyed by boat from 27 April - 17 May 1991 in northeastern Illinois.

| Wetland type (n) |  | Mixed sex flocks |  | Single sex flocks |  | Unknown | Total |
|---|---|---|---|---|---|---|---|
| Species | Pairs | Males | Females | Males | Females | sex | birds |
| Lakes (13) |  |  |  |  |  |  |  |
| Canada goose | 130 | 0 | 0 | 0 | 0 | 314 | 574 |
| Mallard | 13 | 21 | 22 | 63 | 6 | 0 | 138 |
| Mallard hybrid | 0 | 0 | 0 | 10 | 0 | 8 | 18 |
| Ruddy duck | 3 | 0 | 0 | 3 | 0 | 0 | 3 |
| Wood duck | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| River segments (2) |  |  |  |  |  |  |  |
| Canada goose | 52 | 0 | 0 | 0 | 0 | 33 | 137 |
| Mallard | 38 | 5 | 2 | 90 | 3 | 0 | 189 |
| Mallard hybrid | 6 | 18 | 2 | 50 | 0 | 0 | 148 |

Appendix W. Continued.

| Wetland type (n) | | Mixed sex flocks | | Single sex flocks | | Unknown | Total |
|---|---|---|---|---|---|---|---|
| Species | Pairs | Males | Females | Males | Females | sex | birds |
| Semipermanent marsh (2) | | | | | | | |
| Blue-winged teal | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Canada goose | 1 | 0 | 0 | 0 | 0 | 2 | 4 |
| Mallard | 3 | 0 | 0 | 14 | 2 | 0 | 22 |
| Wood duck | 0 | 0 | 0 | 1 | 0 | 0 | 1 |

Appendix X. Numbers of waterfowl observed as pairs, males and females in mixed and single sex flocks, unknown sex, and total birds by species on lakes, river segments, and semipermanent marshes surveyed by boat from 25 May - 12 June 1991 in northeastern Illinois.

| Wetland type (n) | | Mixed sex flocks | | Single sex flocks | | Unknown sex | Total birds |
|---|---|---|---|---|---|---|---|
| Species | Pairs | Males | Females | Males | Females | | |
| Lakes (13) | | | | | | | |
| Canada goose | 55 | 0 | 0 | 0 | 0 | 49 | 159 |
| Mallard | 11 | 17 | 9 | 19 | 9 | 0 | 76 |
| Mallard hybrid | 1 | 8 | 2 | 9 | 0 | 0 | 32 |
| River segments (2) | | | | | | | |
| Canada goose | 19 | 0 | 0 | 0 | 1 | 25 | 64 |
| Mallard | 10 | 50 | 9 | 77 | 10 | 0 | 219 |
| Mallard hybrid | 1 | 2 | 1 | 14 | 1 | 0 | 48 |
| Semipermanent marsh (2) | | | | | | | |
| Canada goose | 3 | 0 | 0 | 0 | 0 | 7 | 13 |
| Mallard | 0 | 0 | 0 | 4 | 1 | 0 | 5 |

BOUND BY
HNM
5-94